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Study of the predictive values of the testing programs of Missoula county high school and Montana state university

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A STUDY OF THE PREDICTIVE VALUES OF THE TESTING PROGRAMS OF MISSOULA COUNTY HIGH SCHOOL AND MONTANA STATE UNIVERSITY

by

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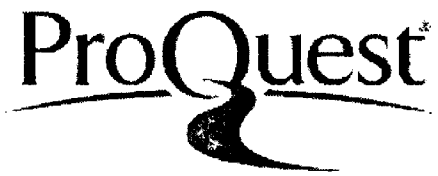

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION AND THE BACKGROUND OF THE STUDY

A problem of supreme importance to the educator and to the student concerned is the one of whether or not the student will make satisfactory progress in an institution of higher learning. Many of those who elect to attend a college or a university are doomed to failure before they enroll. In fact, Bird has commented that "of the many thousands of young people who enter college only a minority are actually entitled to believe that they will graduate within the usually alloted four years."[1]

In a recent study made at Montana State University, it was shown that 51 per cent of the freshmen studied had, at the termination of their first year studies, grade point averages below C, the required average for graduation.[2]

A study at the University of Washington of 5,424 freshmen that entered in September, 1946, revealed that by

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1 Bird and D. Bird, Learning More by Effective Study, (New York: D. Appleton-Century Company, Inc., 1945), p. 237

2 Joseph R. Crowley, "An Evaluation of the American Council on Education Psychological Examination and the Cooperative English Test as Guidance Instruments at Montana State University," (unpublished Master's thesis, Montana State University, Missoula, 1951), p. 3.

September of 1947, twelve hundred were no longer enrolled in the University. One year later found that 1,625, or 30 per cent of the original number of students were no longer in the University. By September, 1949, 1,843, or 34 per cent had dropped out.[3]

Since a college education is costly in both time and money, neither society nor the individual concerned can afford to "foot the bill" in instances where failure is the final outcome.

If failure is to be avoided, one must be concerned with the question--is the prediction of the future status of the individual really possible? The answer would seem to be that perfect efficiency of prediction is not possible, but it is feasible to speak concerning an individual's chances of reaching a specified level of achievement. Each year, colleges and universities find that a few students with very low entrance test scores or ranks in high school graduating classes are successful in academic work; also, a few who score very high prove to be failures as students. In general, however, it can be stated that the chances of success are good for the high-ranking student and poor for the low-ranking student. Prediction in the perfect sense is not

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3 Melvin A. Angell and others, "An Evaluation of General and Specific Entrance Requirements of the University of Washington," (unpublished Doctor's dissertation, The University of Washington, Seattle, 1950), p. 4

possible in the above situation or in most other situations, but prediction in terms of estimating chances for success is possible. It is hoped that through studies such as this some of the uncertainty can be eliminated from the process of prediction.

Since future status is to be predicted from present characteristics and past or present performances, we must know something about the relationship between the traits or characteristics of individuals and their later adjustment or achievement. In other words, the factors that are related to successful performance in an activity must be determined so that the knowledge of these relationships can be used to forecast a particular individual's chances for success before he actually engages in that activity. It must be known that individuals comprising a group differ among themselves in their ability to perform in a given activity and that a satisfactory measure or criterion of success or failure in that activity can be established.

Once an acceptable criterion of success has been established, the prediction factors associated with individual differences in the performance of the activity must be identified and measured. The next step is that of determining the degree of relationship (correlation) between the prediction factors and the criterion. The closeness of the degree of relationship determines how accurately predictions can be made.

I. STATEMENT OF THE PROBLEM

The purpose of this study was (1) to evaluate the Otis Self-Administering Tests of Mental Ability, the Unit Scales of Attainment--Reading Comprehension, the Cooperative English Test, and the Iowa Algebra Aptitude Test administered to freshman classes at the Missoula County High School, plus high school graduation rank as factors related to the prediction of academic success; (2) to evaluate the American Council on Education Psychological Test and the Cooperative English Test administered to entering freshmen at Montana State University as factors related to the prediction of academic success; (3) to determine the highest possible multiple correlation of selected factors or variables obtained from both the university and high school programs as listed above; and (4) to compute multiple regression equations for 1, 2, and 3 above.

The criterion will be first year grade point average obtained from studies at Montana State University. No attempt will be made to segregate the average grades into subject fields, and consequently no attempt will be made to calculate differential prediction equations.

The resulting multiple regression equations will possibly be applicable only to graduates of the Missoula County High School as there is no evidence that they could be applied to populations matriculating to the University from

other high schools.

II. IMPORTANCE OF THE STUDY

If young people are to plan their futures wisely, and if they are to make appropriate educational decisions, they should have as much relevant information about themselves as the counselors and teachers can make available to them.

One duty of a counselor is to help a student look ahead in order to determine where his choices will lead him. If he elects to pursue a course in higher education, will his chances of graduation be good, excellent, or poor? For counselors, these questions pose problems of "prediction." If we can predict relative degrees of success that students will have at Montana State University, we have taken a step toward obtaining effective guidance.

As it has been pointed out in the introduction of this study, student mortality is a problem that educators and guidance personnel must be prepared to combat. They must have available all of the information possible concerning the student--his past achievement, aptitudes, attitudes, interests, and the traits that make up his personality. This information is valueless if it cannot be assimulated and then projected into the future to make predictions.

The Missoula County High School, due primarily to its proximity to Montana State University, has a high percentage of its graduates enter the university each fall. But mere accessibility alone is not a valid reason for those who select a goal of graduation from the University. This study should provide the personnel of both the Missoula County High School and Montana State University with prediction equations that will lead to a better measure of the chances each individual student has to succeed at the University.

III. BACKGROUND OF THE STUDY

Each year, the freshmen at the Missoula County High School are subjected to a battery of tests composed of the Otis Self-Administering Test of Mental Ability, the Unit Scales of Attainment-Reading Comprehension, Iowa Algebra Aptitude Test, and the high school form of the Cooperative English Test. The results are entered on each student's permanent record and also kept in the files of the guidance center. These results are used by the staff in the guidance of each student while in school and for future educational and vocational plans.[4]

The first week of the autumn quarter at Montana State University is set aside for the orientation of entering

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4 Information was obtained from a personal interview with Mr. D. H. Beary, principal, Missoula County High School, July 2, 1953.

freshmen. During this week, they are given the American Council on Education Psychological Examination (here-in-after referred to as the A. C. E.) and the Cooperative English Examination (college form). These tests are given on Tuesday by the staff of the Counseling Center of the University and must be evaluated by the following Thursday. The results are distributed to the faculty advisors where they are used in the educational guidance of the students. Later each student's test results on the A. C. E. and the Cooperative English Test are listed alphabetically in booklets that are made available to any member of the staff that desires them. A card which lists the total English and total reading scores on the Cooperative English Test, the Q, L, and T scores on the A. C. E., and high school graduation percentile rank is kept in the files of the Counseling Center for each student. The services of the Counseling Center are available at all times for students desiring them.[5]

IV. SOURCES OF DATA

Mr. D. H. Beary, principal of Missoula County High School, provided the writer with a list of the graduating class of 1952 and furnished the scores on the Otis Self-Administering Test of Mental Ability, Unit Scales of

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5 Information obtained from a personal interview with Mr. Kermit Severson, director, Council Center, Montana State University, July 23, 1953.

Attainment-Reading Comprehension, Iowa Algebra Aptitude, and Cooperative English Test, plus the high school graduation rank. The list of students was taken to the Registrar's office at the University where Mr. Leo Smith, registrar of Montana State University, made the permanent records available. It was there determined which students actually entered the University in the fall of 1952. Their grades and total grade points were found for their first year of university study. Mr. Kermit Severson, director of the Counseling Center of the University, provided the total scores on the A. C. E. and Cooperative English Test.

V. DEFINITION OF TERMS USED

A term to be encountered in this study is "failure" in the University. Montana State University requires an "all university" average grade point of 2.0 (equivalent to "C" grades) for graduation. Students cannot graduate with grade point averages below 2.0. In this study, "failures" in "All University Average" are indicated by average grades less than 2.0. It is recognized that "D" grades (1.0) are considered as "barely passing". Such grades are not conducive to university success or graduation.

Another term to be encountered throughout this thesis is "success" or "University success". The terms are used to indicate a grade or grades that meet the University's standards for graduation. There will be no attempt to eval-

uate intangible, often-mentioned, unproven, or unsubstantiated benefits of attendance at the University, or in classes concomitant with high or low grades (usually mentioned with low grades). If these benefits exist, they ordinarily may be acquired only if students maintain such grades and grade averages as will enable the students to remain in good standing academically and as will convince students and their parents of the advisability of continued attendance at the University. Grades and grade averages are not "success" but they are essential criteria of success at Montana State University.

Other terms that are used in this study that might need definition are multiple correlation, regression equations, and beta weights.

Multiple correlation is the relationship that exists between a dependent variable and a group (two or more) of independent variables.[6] For example, we may find the correlation that exists between academic grades (the dependent variable) and a combination of achieve ent and aptitude tests (the independent variables).

Regression equations are used to estimate or predict the score on one variable that is most likely to be associated with a given score on another variable with which the

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6 J. P. Guilford, Psychometric Methods (New York: McGraw-Hill Book Company, Inc.), p. 379.

first is correlated. Regression equations involve the use of means, standard deviations, and the coefficient of correlation.[7] When the regression equation has been derived, scores from the independent variables may be substituted in the regression equation to arrive at the predicted score for the dependent variable.

Beta weights, or beta coefficient, are the coefficients or multipliers of the test scores of the regression equation when the equation is expressed in standard form. By standard form is meant that instead of actual or obtained scores, derived scores based upon standard deviations are substituted in the regression equation to obtain the predicted value. The beta weights are indicators of the relative importance of the independent variables as contributors to the prediction of the dependent variable's value.[8]

VI. ORGANIZATION OF THE REMAINDER OF THE THESIS

Chapter II will present a review of the literature pertaining to the problem. Studies in general and differential prognosis from various testing instruments will be summarized and related to the problem. Chapter III will consist of descriptions of the variables that formed the

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7 C. W. Odell, An Introduction to Educational Statistics (New York: Prentice-Hall, Inc.), p. 55.

8 Guilford, op. cit., p. 382.

basis of the calculations. Chapter IV will show the methods and procedures used in determining intercoefficients of correlation of the tests, high school rank, and the criterion. The results of these calculations will be listed and discussed. Chapter V will be concerned with the methods and procedures of finding multiple coefficents of correlation that exist between first year average grade (the criterion) and the eight variables of the study. Selected combinations will be explored and regression equations for each will be calculated. Chapter VI will give the summary of the results, the conclusions, and the recommendations for further research.

CHAPTER II

REVIEW OF THE LITERATURE

The nineteen-twenties are well remembered as crucial years affecting our lives both singly and collectively in far-reaching ways. What may not be so well recognized is that this period also marked a significant turning point in the science of mental measurement.[1] Mental measurement of this period was engrossed in the study of intelligence and was based upon the utilization of statistical concepts and techniques that now seem elementary. Since the 1920 decade, individual measurement and guidance methods have made great progress. This was in part due to the finer statistical concepts available, but even more so to the mounting interest in "human measurement" problems. That this interest in measurement would turn to the fields of prediction seems a natural turn of events. In fact, Travers[2] in 1949 concluded that over 1,000 prediction studies had been made since 1935. There is no indication that the pace of this phase of educational research is slowing down. However, until 1941 Martin

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1 A. B. Crawford and P. S. Burnham, Forecasting College Achievement (New Haven: Yale University Press, 1946), p. 1.

2 R. M. W. Travers, "Prediction of Achievement", School and Society, 70:293-4, November 5, 1949.

was correct in stating:

> As yet we have not produced a measuring scale or technique of analysis that will isolate satisfactorily the components of a given situation of failure or success in order that we might study the roles of both capacity and the will to succeed.[3]

This quotation was indicative of the increasing unrest and the ensuing search for new prognostic devices to analyze performance. Some investigators have sought solutions in new types of factors of prediction other than the purely academic; others have retained old and scholastic variables but have adapted new statistical techniques, while there remain those who are still seeking the solution in a single factor. Since many of the factors that are combined in the makeup of the individual, such as, good work habits, use of time, and motivation, are difficult to measure, the bulk of prediction research has been concerned with the use of aptitude and achievement test results as predictive factors. The number of studies reporting zero order correlations between university performance and various predicting factors was so great that the findings of these studies has been summarized in Tables I to X, pages 17-29.

This study is limited to the evaluation of the Otis Self-Administering Tests of Mental Ability, the Unit Scales of Attainment-Reading Comprehension, the Iowa Algebra Apti-

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3 R. R. Martin, "Predicting Success in College," Education, 62:52-58, September, 1941.

tude Test, The Cooperative English Test (high school form), the A. C. E., and the Cooperative English Test (college form); but it seems that results of other studies that dealt with tests other than the above mentioned would be valuable in gaining an over-all view of the related research. In addition, research in the field of differential predictions would seem to be of value for comparison even though this study will be concerned with general predictions of academic success. As a result, a summary of such studies is also included in the Table XI, pages 30-34.

Generally, the zero order correlations obtained between university performance and various standardized tests ranged from the thirties to the low forties. Contrastingly, the simple coefficients of correlation between high school grades and university performance have shown consistently higher correlation, predominantly in the fifties or sixties, than have similar correlations with standardized tests. Segel,[4] Wells,[5] Crawford and Burnham,[6] and Aaron[7] agree that

4 David Segel, "Prediction of Success in College", United States Department of the Interior, Office of Education Bulletin, No. 15 (Washington, D. C.: United States Printing Office, 1934), p. 70.

5 Walter Wells, "Developments in Higher Education--'Wise and Otherwise,'" American Association of Collegiate Registrars Journal, 17:455-92, July, 1942.

6 Crawford and Burnham, op. cit., p. 129.

7 Sadie Aaron, "The Predictive Value of Cumulative Test Results," Stanford University Bulletin, Eighth Series, No. 3 (Stanford, California: Stanford University, November 29, 1947), p. 140.

high school grades are the best variables for predicting university performance. Until better standardized tests than those in use today are developed, high school grades will continue to be the best single predictor of university success.[8]

Other investigators have used differential methods of prediction. For the most part, their findings have reported only multiple correlation coefficients to the exclusion of the beta coefficients. However, an evaluation of the factors contributing to success inherent in beta coefficients has been made. Nineteen multi-factor studies have been summarized in Table XI. From these studies it can be concluded as did Durflinger[9] in 1943:

1. Multiple correlation coefficients were rarely higher than .80 regardless of the variable used.

2. An intelligence test, a good achievement test, and high school grades together, usually bring the highest multiple R's.

3. The median multiple R as found in the summaries is between .60 and .70.

As may be surmised, multiple correlation studies do present better prediction equations than do single variables.

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8 A. P. Johnson, Predicting Achievement for Freshmen Engineering Students at Purdue University (Purdue University Studies in Higher Education XLIV, 1942), p. 22.

9 G. W. Durflinger, "The Prediction of College Success: A Summary of Recent Findings," American Association of College Registrars Journal, 19:68-78, October 1943.

Butsch[10] reports that regression equations derived from a former class when tried on a following freshman class usually resulted in predictions, which were on the average, within 0.3 grade points of the actual grade achieved. However, the research would seem to indicate that what may be a perfectly good prediction factor for one college may not be for another college. Judging from the evidence, each pattern of abilities is unique and different for each college or school.

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10 R. L. C. Butsch, "Improving the Prediction of Academic Success Through Differential Weighting," Journal of Education Psychology, 30:401-420, September, 1939.

TABLE I

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN ALL UNIVERSITY SUCCESS AND VARIOUS STANDARDIZED TESTS

Investigator	r	Test
Angell et al. (2)*	.25-.41	American Council on Education Psychological Examination**
Hepner (36)	.40	A. C. E.
Laycok and Hutcheon (43)	.50	A. C. E.
Reitz (60)	.49-.64	A. C. E.
Froehlich (28)	.55	A. C. E.
Diederich (19)	.55	A. C. E.
Salley and Weintraub (62)	.33	A. C. E.
Leonard (45)	.44	A. C. E.
Votaw (75)	.53	A. C. E.
	.53	Cooperative English Examination
	.56	Use of Library and Study Materials Test
Constant (22)	.48	A. C. E.
Peterson (22)	.30-.47	A. C. E.
Thurstone and Thurstone (73)	.32	A. C. E.
Berdie (4)	.21	A. C. E.
	.28	Cooperative English Test
	.45	Cooperative Mathematics Test
	.34	Cooperative Chemistry Test
	.22	Minnesota Paper Form Board
	.35-.40	Minnesota Test for Clerical Workers
Wallace (77)	.23-.41	A. C. E.
Borg (8)	.16-.26	A. C. E.
Segel and Proffitt (66)	.39	A. C. E.
McClanahan and Morgan (50)	.65	A. C. E.
Brown (9)	.37-.54	A. C. E.
Lins (46)	.42-.49	A. C. E.
Berdie and Thurstone (5)	.15-.65	A. C. E.

* References in Tables are found in the numbered Bibliography, et passim.

** Known for the remainder of this study as the A. C. E.

TABLE I (Continued)

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN ALL UNIVERSITY SUCCESS AND VARIOUS STANDARDIZED TESTS

Investigator	r	Test
Segel (65)*	.32-.62	A. C. E.
	.44	Army Alpha
	.47	Ohio State University Psychological Examination
	.51	Terman Group Test of Mental Ability
	.39	Thorndike Intelligence Examination for High School Graduates
	.38	Otis Mental Ability Tests
	.39	General Achievement Tests
Williamson (78)	.43-.50	College Aptitude Test
Terman (71)	.45	Terman Group Test of Mental Ability
Byrns (14)	.36	Ohio State University Psychological Examination
Stuit (68)	.41-.62	Ohio State University Psychological Examination
Quaid (58)	.70	Ohio State University Psychological Examination
Read (59)	.42-.57	Ohio State University Psychological Examination
	.16-.42	Iowa Silent Reading Test
	.43-.58	Iowa High School Content Examination
Wagner and Strabel (76)	.35	A. C. E.
	.60	New York Regents Examination
	.50	Iowa High School Content Examination

* References in Tables are found in the numbered Bibliography, et passim.

TABLE I (Continued)

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN ALL UNIVERSITY SUCCESS AND VARIOUS SECONDARY TESTS

Investigator	r	Test
Travers and Wallace (74)*	.39-.48	A. C. E.
	.27	MacQuarrie Test for Mechanical Aptitude
	.28	Bennett Test of Mechanical Comprehension
	.25	Minnesota Paper Form Board Test
	.45	A. E. D. (Natural Science)
Ficken (26)	.12-.35	Minnesota College Aptitude Test
Smith (22)	.44	Thurstone Primary Mental Abilities Tests
Crawford and Burnham (17)	.50	A. C. E.
	.49	Iowa High School Content Examination
	.47	College Entrance Board Examination
Laundry (22)	.57	College Entrance Board Examination
Butsch (13)	.46-.54	Thurstone Primary Mental Abilities Tests
	.34-.48	Iowa High School Content Examination
Root (61)	.52	Otis General Intelligence Test
Hass (35)	.32-.34	Herman-Nelson Test of Mental Ability
Leaf (44)	.63	Iowa High School Content Examination
Buckton and Doppelt (11)	.41	Brooklyn College Admission Test
Sappenfield (63)	.18-.82	New York University College Aptitude Examination
Morris (22)	.39-.53	New York Regents Examination

* References in Tables are found in the numbered Bibliography, et passim.

TABLE I (Continued)

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN ALL UNIVERSITY SUCCESS AND VARIOUS STANDARDIZED TESTS

Investigator	r	Test
Cochran and Davis (15)*	.36-.44	A. C. E.
	.28-.34	Cooperative Reading Comprehension Test
	.32-.34	Cooperative General Achievement Test
	.31	Cooperative Test on Recent Social and Scientific Development
	-.20-.11	Minnesota Personality Scale
Hartson and Sprow (34)	.29-.48	not listed

* References in Tables are found in the numbered Bibliography, et passim.

TABLE II

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN UNIVERSITY ENGLISH AND VARIOUS STANDARDIZED TESTS

Investigator	r	University Area*	Test
Angell et al. (2)**	.21-.44		A. C. E.
Segel and Proffitt (66)	.48		A. C. E.
Wallace (77)	.29-.48	Literature	A. C. E.
Berdie (5)	.08-.68		A. C. E.
Salley and Weintraub (62)	.26		A. C. E.
	.49		New York Regents Examination
Diederich (19)	.65	Reading	special test of university material
	.45	Writing	special test of university material
Lanigan (41)	.29		Otis Test of Mental Ability
	.33		A. C. E.
	.54		Minnesota Speed of Reading Test
Stone (67)	.50		Army Alpha
Jordan (39)	.52		Army Alpha
Nelson (54)	.37		Nelson-Denny College Reading Test
Gilkey (32)	.49		New York Regents Examination

* Except as otherwise designated, the university area is a composite of English grades. The designations indicate specific areas of university English.

** References in Tables are found in the numbered Bibliography, et passim.

TABLE III

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN UNIVERSITY MATHEMATICS AND VARIOUS STANDARDIZED TESTS

Investigator	r	University Area*	Test
Angell et al. (2)**	.23-.30		A. C. E.
Wallace (77)	.18-.39		A. C. E.
Berdie (5)	-.16-.64		A. C. E.
Salley and Weintraub (62)	.45		A. C. E.
	.74		New York Regents Examination
Lanigan (41)	.32		A. C. E.
	.24		Otis Test of Mental Ability
	.19		Minnesota Speed of Reading Test
Root (61)	.39-.61		Thorndike College Entrance Test
Segel (65)	.22		Iowa High School Content Examination
Jordan (39)	.21		Army Alpha
Stone (67)	.38		Army Alpha
Odell (55)	.31	Algebra	Otis Quick Scoring Group Test
Gilkey (32)	.34		New York Regents Examination

* Except as otherwise designated, the university area is a composite of Mathematics grades. The designations indicate specific areas of university mathematics.

** References in Tables are found in the numbered Bibliography, et passim.

TABLE IV

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN UNIVERSITY FOREIGN LANGUAGE AND VARIOUS STANDARDIZED TESTS

Investigator	r	University Area*	Test
Angell et al. (2)**	.13-.24		A. C. E.
Segel and Proffitt (66)	.43		A. C. E.
Wallace (77)	.18-.31	French	A. C. E.
	.08-.16	Spanish	A. C. E.
Berdie (5)	.00-.47	German	A. C. E.
Lanigan (41)	.22		A. C. E.
	.23		Otis Test of Mental Ability
	.42		Minnesota Speed of Reading Tests
Gilkey (32)	.32		New York Regents Examination
Salley and Weintraub (62)	.09	French	A. C. E.
	.30	Spanish	A. C. E.
	.54	French	New York Regents Examination

* Except as otherwise designated, the university area is a composite of Foreign Language grades. The designations indicate specific areas of university Foreign Language.

** References in Tables are found in the numbered Bibliography, et passim.

TABLE V

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN UNIVERSITY SOCIAL SCIENCE [illegible] AND VARIOUS STANDARDIZED TESTS

Investigator	r	University Area*	Test
Angell et al. (2)**	-.06-.43		A. C. E.
Segel and Proffitt (66)	.32		A. C. E.
	.24	Economics	A. C. E.
Wallace (77)	.13-.34	History	A. C. E.
	.22-.36	Pol. Sci.***	A. C. E.
Berdie (5)	.07-.63		A. C. E.
Salley and Weintraub (62)	.45	Economics	A. C. E.
	.58	History	A. C. E.
	.63	Pol. Sci.	A. C. E.
	.22	Psychology	A. C. E.
	.59	Economics	New York Regents Examination
	.90	History	New York Regents Examination
	.55	Psychology	New York Regents Examination
Lanigan (41)	.42		Otis Test of Mental Ability
	.50		A. C. E.
	.39		Minnesota Speed of Reading Test
Segel (65)	.19		Iowa High School Content Examination
Jorden (39)	.54	History	Army Alpha
Stone (67)	.31	History	Army Alpha
Odell (55)	.33	Pol. Sci.	Otis Quick Scoring Group Test
Silkey (32)	.32		New York Regents Examination
Thompson (72)	.38	Psychology	Group Rorschach

* Except as otherwise designated, the university area is a composite of Social Science grades. The designations indicate specific areas of university Social Science.

** References in Tables are found in the numbered Bibliography, et passim.

*** Political Science is abbreviated to Pol. Sci.

TABLE VI

SUMMARY OF COEFFICIENTS OF CORRELATION (r)
BETWEEN DIFFERENT UNIVERSITY NATURAL SCIENCE COURSES
AND VARIOUS STANDARDIZED TESTS

Investigator	r	University Area	Test
Angell et al. (2)*	.19-.44		A. C. E.
Wallace (77)	.20-.32	Botany	A. C. E.
	.37-.45	Chemistry	A. C. E.
	.12-.15	Geography	A. C. E.
	.31-.35	Geology	A. C. E.
	.11-.27	Zoology	A. C. E.
Berdie (5)	.12-.75	Biology	A. C. E.
	.02-.68	Chemistry	A. C. E.
	.03-.38	Physics	A. C. E.
Segel and Proffitt (66)	.43	Biology	A. C. E.
	.43	Physics	A. C. E.
Salley and Weintraub (62)	.39	Biology	A. C. E.
	.06	Chemistry	A. C. E.
	.60	Biology	New York Regents Examination
	.29	Chemistry	New York Regents Examination
Root (61)	.24	Chemistry	Thorndike Intelligence Examination
	.50	Physics	Thorndike Intelligence Examination
Gilkey (32)	.15	Exact Science	New York Regents Examination
Stone (67)	.38	Chemistry	Army Alpha
Odell (55)	.37	Zoology	Otis Quick Scoring Group
Bear (3)	.25-.50	Physics	Iowa Physics Aptitude Test

* References in Tables are found in the numbered Bibliography, et passim.

TABLE VII

SUMMARY OF COEFFICIENTS OF CORRELATION (r)
BETWEEN DIFFERENT UNIVERSITY APPLIED SCIENCE AREAS
AND VARIOUS STANDARDIZED TESTS

Investigator	r	University Area	Test
Angell et al. (2)*	.04	Architecture	A. C. E.
	.19-.34	Engineering	A. C. E.
	.35	Forestry	A. C. E.
	.15-.16	Home Ec.**	A. C. E.
	.15-.22	Pharmacy	A. C. E.
Froelich (28)	.495	Engineering	A. C. E.
	.64	Home Ec.	A. C. E.
	.56	Pharmacy	A. C. E.
Laycock and Hutcheon (43)	.34	Engineering	A. C. E.
Salley and Weintraub (62)	.46	Home Ec.	A. C. E.
	.70	Home Ec.	New York Regents Examination
Stuit and Hudson (68)	.15-.58	Engineering	Thurstone Primary Mental Abilities Tests
Lord et al. (47)	.38-.63	Engineering	Pre-Engineering Inventory
Wallace (77)	-.12-.10	Drawing	A. C. E.
Moore (53)	.19-.47	Pharmacy	Johnson Science Survey Test
	-.02-.37	Pharmacy	Iowa Chemistry Test
	.35	Pharmacy	Pharmacy Mathematics Test II
	.04-.15	Pharmacy	Pharmacy Problem Solving Test

* References in Tables are found in the numbered Bibliography, et passim.

** Home Economics is written Home Ec.

TABLE VIII

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN VARIOUS STANDARDIZED TESTS AND CRITERIA IN FINE ARTS AND OTHER SUBJECT AREAS

Investigator	r	University Area	Test
Angell et al. (2)*	.03-.13	Art	A. C. E.
	.30-.38	Classical Language	A. C. E.
	.20-.21	Music	A. C. E.
	.34-.40	Philosophy	A. C. E.
Wallace (77)	.16-.23	Humanities	A. C. E.
Salley and Weintraub (62)	.40	Art	A. C. E.
	.73	Art	New York Regents Examination
Lanigan (41)	.38	Fine Arts	Otis Test of Mental Abilities
	.36	Fine Arts	A. C. E.
	.32	Fine Arts	Minnesota Speed of Reading Test
Froehlich (28)	.61	Music	A. C. E.

* References in Tables are found in the numbered Bibliography, et passim.

TABLE IX

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN HIGH SCHOOL AVERAGE AND UNIVERSITY ACADEMIC SUCCESS

Investigator	r	College Area
Crawford (16)*	.65	Freshman
Edds and McCall (23)	.65	Freshman
Stuit et al. (69)	.33-.61	Engineering Freshman
Wagner and Straubel (76)	.52	Freshman & High School English
Ficken (26)	.67	First Semester
	.68	Graduation
Froehlich (28)	.61	Freshman
	.61	Freshman Arts and Letters
	.58	Freshman Engineering
	.63	Freshman Home Economics
	.62	Freshman Music
	.55	Freshman Pharmacy
Hepner (36)	.52	Freshman
Reitz (60)	.34-.51	Freshman
Douglas (20)	.38-.54	
Galley and Weintraub (62)	.61	Graduates
Segel and Proffitt (66)	.52	Freshman
	.49-.52	First Quarter
	.49	Four Years
Piersen (57)	.53	Engineering
McClanahan and Morgan (50)	.36	Freshman
Berdie (4)	.56	
Crawford and Burnham (17)	.50	Two Years
Moore (53)	.44-.48	Two Years Pharmacy
Lins (46)	.58-.62	Freshman
Buckton and Doppelt (11)	.63	Freshman
Garret (30)	.61-.73	Four Years
Laycock and Hutcheon (43)	.61	Freshman Engineers
Lauer and Evans (42)	.49	Freshman
Odell (55)	.55	Freshman
Schmitz (64)	.64	

* References in Tables are found in the numbered Bibliography, et passim.

TABLE X

SUMMARY OF COEFFICIENTS OF CORRELATION (r) BETWEEN NINE UNIVERSITY AREAS AND SIX H. S. AREAS (AFTER SEGEL AND PROFFITT[1])

University	High School					
	English	Mathematics	Foreign Languages	Social Studies	Science	Vocational
Freshman Average	.34	.42	.37	.37	.43	.18
Four Year Average	.42	.38	.31	.37	.33	.13
Biology	.42	.45	.42	.32	.49	.38
Economics	.32	.30	.29	.41	.24	.07
English	.46	.44	.43	.35	.31	.14
Foreign Language	.52	.31	.43	.44	.30	.05
Mathematics	.40	.43	.37	.35	.36	.16
Physical Sciences	.37	.46	.35	.41	.40	.08
Social Studies	.38	.29	.30	.38	.22	.05

1 David Segel and Morris M. Proffitt, Some Factors in the Adjustment of College Students, United States Department of the Interior, Office of Education Bulletin No. 12 (Washington, D. C.: United States Government Printing Office, 1937), pp. 15-30.

TABLE XI

SUMMARY OF MULTIPLE CORRELATION COEFFICIENTS (R) SHOWING THE RELATIONSHIPS BETWEEN VARIOUS COMBINATIONS OF PREDICTIVE INDICES AND SUCCESS (S)* IN UNIVERSITY

Prediction Variable	Criterion Grade Point	R
Douglass (20)** intelligence tests, achievement tests in various subjects, special ability tests, average marks in high school, average marks in college, marks in certain subjects, interest inventories, age, sex and living conditions	eleven faculties at Minnesota	.65-.70
Bernreuter and Goodman (6) various combinations of: Columbia Research Bureau Tests, Thorndike Intelligence Examinations, Minnesota Paper Form Board, Cox Mechanical Aptitude Tests, Minnesota Interest Analysis Blank, Minnesota Assemble Test, MacQuarrie Test for Mechanical Ability, Minnesota Spatial Regulations Test, O'Connor Tests.	four year engineers	.43-.61
Laycock and Hutcheon (43) A. C. E., Grade XII marks, Form Relations Test of National Institute of Industrial Psychology of Great Britain, Cox Mechanical Aptitude Test, Bernreuter Personality Inventory, Thurstone Interest Inventory.		.66

* Some studies presented correlative data with success in different university or college areas. These are indicated by ranges in the correlation coefficient.

** References in Tables are found in the numbered Bibliography, et passim.

TABLE XI (Continued)

SUMMARY OF MULTIPLE CORRELATION COEFFICIENTS (R) SHOWING THE RELATIONSHIPS BETWEEN VARIOUS COMBINATIONS OF PREDICTIVE INDICES AND SUCCESS (S)* IN UNIVERSITY

Prediction Variable	Criterion Grade Point	R
Read (59)** Iowa Silent Reading Test, Iowa High School Content Examination, Ohio University Psychology Examination, Purdue Placement Test in English.	freshmen	.57
Humber (37) Cooperative English Examination, Robinson-Hall Science and Social Studies Tests, Cooperative Literary Examinations, Chapman-Cook Rate of Reading Examination, Michigan Science and Social Science Vocabulary Tests, Iowa Silent Reading Test, A. C. E.	seniors	.65
McClanahan and Morgan (50) tests in English, chemistry aptitude, reading A. C. E., high school rank.	engineers	.85
Durflinger (22) Iowa High School Content Examination, T.C.A.P. Intelligence Test, Ohio State University Psychological Examinations, and other intelligence aptitude, specific subject aptitude tests and high school rank or average. Using various combinations of above, the following investigators report:		

* Some studies presented correlative data with success in different university or college areas. These are indicated by ranges in the correlation coefficient.

** References in Tables are found in the numbered bibliography, et passim.

TABLE XI (Continued)

SUMMARY OF MULTIPLE CORRELATION COEFFICIENTS (R) SHOWING THE RELATIONSHIPS BETWEEN VARIOUS CRITERIONS OF PREDICTIVE INDICES AND SUCCESS (S)* IN UNIVERSITY

Prediction Variable	Criterion Grade Point	R
Busen		.59,.70
Byrnes and Henmon		.70
Durflinger		.54,.55
Heilman		.62,.69
Hartson		.75
Hepner		.56
Leaf		.79
Root		.83
Solover and Potter		.70
Edds and McCall (23)** English ability, intelligence, high school marks.	freshmen	.81
Brush (10) nineteen mechanical and engineering tests including Cox Test of Mechanical Aptitude and Minnesota Paper Form Board. Above plus an intelligence test score.	engineers	.30-.54
Reitz (60) A. C. E., high school rank, high school average.	freshmen	.63
Butsch (13) Thurstone Primary Mental Abilities Tests, Iowa High School Content Examinations, high school rank.	first	.59-.70

* Some studies presented correlative data with success in different university or college areas. These are indicated by ranges in the correlation coefficient.

** References in Tables are found in the numbered Bibliography, et passim.

TABLE XI (Continued)

SUMMARY OF MULTIPLE CORRELATION COEFFICIENTS (R) SHOWING THE RELATIONSHIPS BETWEEN VARIOUS COMBINATIONS OF PREDICTIVE INDICES AND SUCCESS (S)* IN UNIVERSITY

Prediction Variable	Criterion Grade Point	R
May (49)** general intelligence, time spent in study.	first semester	.60
G.A.T.B. Senior Project Staff et al. (31) general aptitude test battery.	seniors	.41-.57
Votaw (75) A. C. E., Cooperative English Examination, Use of Library and Story Materials Test.	freshmen	.61
Crawford and Burnham (17) A. C. E., Ohio State Psychological Examination, Minnesota College Test, high school rank.	freshmen	.61-.63
Wagner and Strabel (76) Cooperative English Aptitude Total, New York Regents English Examination.	four years	.69
Hepner (36) A. C. E., Bell Adjustment Inventory, Barrett-Ryan English Test, Progressive Mathematics Test, SHak tests of Reading comprehension, Sones-Harry High School Achievement Test, Vocational Questionnaire, high school record.	freshmen	.56

* Some studies presented correlative data with success in different university or college areas. These are indicated by ranges in the correlation coefficient.

** References in Tables are found in the numbered Bibliography, et passim.

TABLE VI (Continued)

SUMMARY OF MULTIPLE CORRELATION COEFFICIENTS (R) WHEN THE RELATIONSHIPS BETWEEN VARIOUS COMBINATIONS OF ADDITIVE INDICES AND SUCCESS (S)* IN UNIVERSITY

Prediction Variable	Criterion Grade Point	R
Johnson (38)** Iowa Placement Examination Series, A. C. E., Thurstone Primary Mental Abilities Tests, rank in high school graduating class.	first year engineers	.76
Meyer and Schultz (52) Scholastic Aptitude Test, questionnaire, high school average.		.64
McGehee (51) A. C. E., Cooperative English Test, Cooperative Mathematics Test.	first year engineers	.57

* Some studies presented correlative data with success in different university or college areas. These are indicated by ranges in the correlation coefficient.

** References in Tables are found in the numbered Bibliography, et passim.

CHAPTER III

DESCRIPTIONS OF THE DATA

In this chapter, the factors that will enter into the subsequent calculations involved in the determination of the necessary coefficients of correlation and the multiple regression equations will be discussed. These factors are the Otis Self-Administering Tests of Mental Ability, the Iowa Algebra Aptitude, the Unit Scales of Attainment-Reading Comprehension, the Cooperative English Test (high school and college forms), High School Graduation rank, average first year university grade point average, and the population of the study.

I. OTIS SELF-ADMINISTERING TESTS OF MENTAL ABILITY

This test is one of the tests that was administered to the freshman class at the Missoula County High School and is one of the variables selected for use in this study. As the name implies, it is an intelligence test, and one of the oldest tests in wide spread use today having been first placed on the market in 1922. The test is distributed by the World Book Company.

The Higher B form, whose results were used in this investigation, consists of seventy-five mixed items that are

arranged in order of difficulty. The general classifications of the test are verbal, arithmetical, and spatial. Included in these classifications are vocabulary, sentence meaning, proverbs, number series and analogies. The subtests are not timed and the author gives the administrator the option of either giving the entire test on a twenty minute basis or on a thirty minute basis. However, for high school students the thirty minute timing is recommended.

Super[1] maintains that the test is too simple for use with older college students and superior adults, but if it is to be used for testing these persons he believes that the test should be timed on the twenty minute basis.

The reliability of the test, determined by comparing results on the "A" and "B" forms is about .92. The norms have been well established as they are based on the distribution of scores for about one hundred and twenty thousand persons. These scores were taken from large samples of various sections of the United States. The author claims that the method of standardization provides the best indication of the test's validity.[2]

For use in counseling and guidance, Super[3] concludes that it is of value in predicting a student's prospects of

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1 Donald E. Super, "Appraising Vocational Fitness", (New York: Harper & Brothers, 1949), p. 107.

2 Ibid., p. 109.

3 Ibid., p. 113.

success in school or college.

II. UNIT SCALES OF ATTAINMENT-REVISED EDITION

This test, Form A, is also one of the variables selected from the Missoula County High School's testing program. It was developed by M. J. Van Wagenen of the University of Minnesota and bears the copyright date of 1933. The test is distributed by the Educational Test Bureau. The test is not timed, but everyone is expected to finish within forty-five minutes. It consists of eight paragraphs which are arranged according to difficulty. These paragraphs seem to measure the ability to identify the general sense of the paragraph, the ability to determine whether a definite idea is stated, the ability to identify details in the paragraph, and the ability to make simple inferences from the material presented in the paragraph.

III. IOWA ALGEBRA APTITUDE TEST

The revised edition printed in 1942 was administered to the population of this study in their freshman year at the High School. It consists of four parts, each of which is timed. The four parts as they appear in the test are: Arithmetic which measures knowledge of fundamentals such as addition, subtraction, multiplication, division, and use of percentages; Abstract Computation which is the application of fundamentals to written problems; Numerical Series which

measures the student's ability to grasp the sequence of a series of numbers; and Dependence and Variation which measures the student's ability to grasp the relationship of the variables in simple algebraic equations.

Segel[4] believes that it is one of the best tests available for prediction of success in algebra and that it is superior to an intelligence test for that purpose.

IV. COOPERATIVE ENGLISH TEST (HIGH SCHOOL FORM)

Form PM, the form administered to the population of this investigation, was published in 1939 and is composed of three parts: English usage which includes grammar and diction of seventy-five items, punctuation of sixty items, capitalization of thirty items, and sentence structure of fifteen items; Spelling which consists of forty-five items; and a vocabulary test of one hundred words.

The total test is assigned a time limit of seventy minutes and each of the subtests is also timed, but if a student completes a section before expiration of the time limit he may proceed on to the next section. The test may either be scored by hand or by machine. Reliabilities are given as being about .98, but validity coefficients are not given.

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4 David Segel as quoted by Oscar K. Buros, The Nineteen Fortieth Mental Measurements Yearbook (Highland Park, New Jersey: Mental Measurements Yearbook, 1941), p. 278.

The main criticisms of the test are concerned with the question of whether or not the test measures the ability of the student to apply the fundamentals of grammar and English usage in his writings and in his speech. Jones[5], in his review, states:

> We doubt, first, that ability to detect and correct errors in English usage in someone else's writing, or ability to select the most appropriate of several alternative constructions for any given sentence can be taken as very conclusive evidence of a student's ability to write grammatically in his own compositional enterprises. We doubt, also that ability to select the best of four sentences, each expressing the same general idea in a different way, or ability to recast sentences according to a prescribed pattern constitutes too sound an index of a student's ability, on his own part, to compose acceptable sentences. We doubt, furthermore, that the discovery of 30 or 40 misspelled words in a list of 25 can be taken as much of an indication of what a student would normally do in avoiding spelling defections in his own writing. And finally, we doubt that a student's score on the kind of vocabulary test used in this instrument would indicate anything concerning the vocabulary which that student himself would employ in connection with his own efforts at composition; really, the test would seem to give evidence of a student's reading vocabulary, rather than of his compositional vocabulary.

Jones[6], however, concludes that it is the best test of its type that is commercially available.

V. COOPERATIVE ENGLISH TEST (COLLEGE LEVEL)

One of the tests used in the testing program of the

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5 C. C. Jones as quoted by Oscar K. Buros, The Nineteen Fortieth Mental Measurements Yearbook (Highland Park, New Jersey: Mental Measurements Yearbook, 1941), p. 107.

6 Loc. cit.

University is the Cooperative English Test. Higher Level, Form L, the results of which were available for use in this study, is composed of three main tests: reading comprehension, mechanics of expression, and effectiveness of expression.[7]

Pooley in his review of the Cooperative English Test states:

> The test Reading Comprehension contains two parts; vocabulary-meaning tested by five choices, one of which is a synonym of the given word; and speed and level of comprehension--tested by responses to 17 brief reading selections drawn from widely different sources, informational, scientific, and literary. The test Mechanics of expression contains 60 items of grammatical usage placed in sentences, 45 items of punctuation, and 24 items of capitalization, the latter two types presented in running prose. Spelling is presented in 60 items, each in a choice between a misspelled and correctly spelled word. The test Effectiveness of Expression contains three parts. Part I measures sentence structure and style by the comparison of passages of prose placed in parallel columns and by an exercise in the choice among four versions of the same sentence. Part II is a test of active vocabulary in which the student must guess the word intended by definition and by clues to first letter and length of word. Part III measures organization by rearranging disorganized paragraphs and by completing a partial outline.[8]

Pooley[9] believes its virtues lie in simple and concise

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7 L. P. Leonard as quoted by Oscar K. Buros, The Third Mental Measurements Yearbook (New Brunswick: Rutgers University Press, 1949), p. 221.

8 R. C. Pooley as quoted by Oscar K. Buros, The Third Mental Measurements Yearbook (New Brunswick: Rutgers University Press, 1949), p. 223.

9 Loc. cit.

directions, avoidance of dubious and controversial usage, and the natural settings of sentences and paragraphs. He also believes that it is one of the best tests available in the field. He does not say that it tests the ability of creative writing or the effective usage of correct English in speech, but rather tests the power to correct errors, proofread, and to organize or reorganize materials composed by others.

VI. THE AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION

The 1949 edition of the A. C. E., which was used in this study, is composed of six sections. These sections are sentence completion, artificial language, same-opposites (vocabulary), arithmetic reasoning, analogies (symbols, spatial), and number series. The test groups the above sections under the headings of quantitative (arithmetic and spatial), and linguistic which give the Q and L scores respectively. In addition to the Q and L scores there is also a total score which is represented by T. Each test is preceded by a practice test. Both the test and practice test are timed. The administration of the total test requires about one hour. The method of scoring is relatively simple and the administrator has the option of either hand scored or machine scored editions.

In regard to standardization and reliability, Super[10]

[10] Super, op. cit., pp. 115-117.

gives a reliability of .95 for the total score, .87 for the Q score, and .95 for the L score. He believes the tests are well standardized, but only for college freshmen.

Super[11] reported that there is probably more material concerning its educational significance than there is available for any other single test, and that it is a reliable and valid test of scholastic aptitude as well as general intelligence at the college level.

VII. HIGH SCHOOL RANK

The class of 1952 of the Missoula County High School numbered 249. The students were ranked on the basis of "1" high to "249" low. Since it was thought that high school rank would be an important factor in the prediction of academic success at the University, the relative ranking of these students is an integral part of this study. All calculations are, as a result, based on the student's rank at the time of his graduation.

VIII. POPULATION OF THE STUDY

Of the total number graduated in the class of 1952 from the High School, eighty-one were found to have entered the University in the same year. With the exception of one student that dropped out of the University before receiving

11 Ibid., p. 123.

any credits or grades, all of these students were a part of this study. The number of cases resulting, after the elimination of the single drop-out, was eighty. It would have been desirable to increase this number of cases by the addition of members from other graduated classes, but this was not feasible due to the alterations that were made in the University's grading system. Students now receive credit for a C+ grade, which was not done in other years, and would make the calculation of grade point averages impossible to determine on an equal basis.

IX. GRADE POINT AVERAGES

The policy of the University is to assign grade points on the basis of one for a "D", two for a "C", three for a "B", four for an "A", and zero for any "F". An additional one-half grade point is given for a C+. The course credits in a given course are then multiplied by the grade points as listed above to determine the total grade points earned for any given course.

For the purpose of this study, grade points were assigned on the basis of one for an "F", two for a "D", three for a "C", three and one-half for a C+, four for a "B", and five for an "A". This assignment resulted in truer averages since all "F" grades when multiplied by course credits resulted in a value; in the University's system they do not. Though the University's system does not grant credit for

classwork in which an "F" is the final grade, it does not penalize him on the basis of an average grade. This results in average grades which, in the case of failing grades, is not a true indication of the student's academic record. Average grades were computed by multiplying course credits by grade points and dividing this product by credit hours.

All grades earned by the sample of students by the completion of the first year's work were utilized in this study. In some cases, students did not complete their studies for the entire nine months, but the grades and the credits they had earned up until the time of dropping out entered into the calculations. It was the writer's belief that retaining them in the study would result in more accurate correlations and, as a result, in better prediction equations. That this belief seems to have been confirmed will be pointed out later in the study.

CHAPTER IV

METHODS AND PROCEDURES INVOLVED IN CALCULATING SIMPLE COEFFICIENTS OF CORRELATION

The first step involved in progressing toward regression equations or predictions, is that of finding simple coefficients of correlation. These simple coefficients of correlation are also called zero order coefficients of correlation and are coefficients that show the relationship between two variables. This chapter will show the methods and the procedures used in finding the coefficients of correlations (r), the means, and the standard deviations (σ).

I. STATISTICAL PROCEDURE

Technique. To prepare the basic groundwork of this study, it was necessary to compute intercorrelations of the criterion (average first year university grade), the Otis Self-Administering Test of Mental Ability, the Cooperative English Test (both college and high school forms), the Unit Scales of Attainment-Reading Comprehension, the Iowa Algebra Aptitude Test, the A. C. E., and high school graduation rank. Twenty-eight zero order coefficients were necessary for the study.

Raw scores were used for each test with the exception

of the Cooperative English Test for which total English (T.E.) scaled scores were the only available data. The total score (T) on the A. C. E. was used as were the total English (T.E.) scores. All other scores are total scores.

The formula for the calculation of the correlations was obtained from Garrett[1] and may be represented as follows:

$$r^2 = \frac{(N\Sigma XY - \Sigma X\Sigma Y)^2}{(N\Sigma X^2 - (\Sigma X)^2)(N\Sigma Y^2 - (\Sigma Y)^2)}$$

In the above formula, r represents the coefficient of correlation, N is the number of cases, X is the score of one of the variables, Y is the score of the second variable, and ΣX is the summation of the X scores, ΣY is the summation of the Y scores, ΣXY represents the summation of the products of X and Y, $(\Sigma X)^2$ denotes the square of the sum of the X scores, $(\Sigma Y)^2$ expresses the square of the sum of the Y scores, ΣX^2 indicates the sum of the squares of each individual X score, and ΣY^2 is the summation of the squares of each individual Y score. It is seen that one needs the number of cases, the sum of the scores of each of the variables, the sum of the cross products of the scores, the square of the sums of the scores, and the summation of the squares of the scores as the basic components of the formula.

To facilitate the findings of the zero order coef-

1 Henry E. Garrett, Statistics in Psychology and Education (New York: Longmans, Green and Company, 1947), p. 292.

ficients, the necessary totals and computation for each were placed on five by eight cards. There was a total of twenty-eight such cards, but after the compilation of the coefficients of correlation between the criterion and the seven variables of the study, much of the data is transferable from card to card. The cross products were computed and totaled separately for each of the intercorrelations.

An example of the cards is shown in Figure 1 which also shows the data and computations needed for the determination of the correlation between the criterion and high school rank.

All calculations were thoroughly checked to aid in the elimination of human errors, and each process was calculated and recalculated four times.

The mean for each of the seven variables and the criterion was computed by means of the following equation:

$$M = \frac{\Sigma X}{N}^2$$

In this equation M designates the mean, ΣX indicates the sum of the scores for the given variable, and N is the number of cases. It will be seen that the calculation of M is not difficult and is expedited by the fact that all of the components involved in its determination have previously been

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2 Ibid. p. 32.

$$r^2 = \frac{(N\Sigma XY - \Sigma X \Sigma Y)^2}{(N\Sigma X^2 - (\Sigma X)^2)(N\Sigma Y^2 - (\Sigma Y)^2)}$$

X = Average Grades Y = High school rank

$N = 80$ $\Sigma X = 255.88$ $(\Sigma X)^2 = 65474.5744$

$\Sigma XY = 42,315.77$ $N\Sigma XY = 3,385,261.60$ $\Sigma X^2 = 864.9714$

$N\Sigma Y^2 = 69,197.7120$ $\Sigma Y = 12,286$ $Y\Sigma Y = 3,143,141.68$

$(\Sigma Y)^2 = 150,945,796$ $\Sigma Y^2 = 2,221,496$

$N\Sigma Y^2 = 177,719,680$ $N\Sigma XY - (\Sigma X)(\Sigma Y) = 241,519.92$

$N\Sigma X^2 - (\Sigma X)^2 = 3,723.14$ $N Y^2 - (Y)^2 = 26,773,884$

$$r^2 = \frac{(241,519.92)^2}{(3,723.14)(26,773,884)}$$

$r^2 = .58517$ $r = .76497$

$M_x = \frac{\Sigma X}{N}$ $M_x = \frac{255.88}{80}$ $M_x = 3.1985$

$M_y = \frac{\Sigma Y}{N}$ $M_y = \frac{12,286}{80}$ $M_y =$

$\sigma_x = \sqrt{\frac{N\Sigma X^2 - (\Sigma X)^2}{N}}$ $\sigma_x = \sqrt{\frac{3,723.14}{80}}$ $\sigma_x = .7628$

$\sigma_y = \sqrt{\frac{N\Sigma Y^2 - (\Sigma Y)^2}{N}}$ $\sigma = \sqrt{\frac{26,773,884}{80}}$ $\sigma_y = 64.68$

FIGURE 1

ILLUSTRATION OF THE PROCEDURE FOR CALCULATING r USING DATA FROM AVERAGE GRADES (X) AND HIGH SCHOOL RANK (Y)

calculated during the process of determining the coefficient of correlation.

The standard deviations (represented by the Greek letter σ) were computed through application of the following equation:

$$\sigma = \sqrt{\frac{N\Sigma X^2 - (\Sigma X)^2}{N}}$$ [3]

The numerator is taken directly from the calculations of the formula for r. The denominator of that formula gives directly the values of the numerator of the σ formula for both X and Y. These values are then simply divided by N (the number of cases) to get σ for X and Y.

It will be shown in Chapter V that the means and standard deviations are a necessary factor in the computations concerned with establishing regression.

Results. A summation of the zero order coefficients are to be found in Table XII. From the table it can be seen that the zero order coefficients of correlation of the criterion with the seven variables ranged from .4607 to .7650, with a median coefficient of .5062. The highest r was obtained with high school rank and the criterion. The lowest coefficient found was that of the Iowa Algebra Aptitude Test and the criterion. It is interesting to note that there is quite a large difference in the r's obtained for the two

3 Ibid. p. 63.

forms of the Cooperative English Examination and that high school rank would seem to be an adequate predictive factor taken by itself since its correlation with the criterion is rather high.

The intercorrelations of the tests, high school rank, and the criterion range from a low of .4607 to a high of .8357. The median coefficient of correlation was about .64. Crawford[4] points out, the combined predictive powers of the variables is increased by a combined relationship of high correlations of each variable with the criterion and low intercorrelations of the variables themselves. It would seem that the intercorrelations of the variables of this study are too high for an optimum combined predictive value.

The means, standard deviations, and standard errors of the means and deviations are summarized in Table XIII. This table is for the purpose of showing the unreliabilities of the measures of central tendency for each separate test.

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4 Crawford and Burnham, Forecasting College Achievements (New Haven: Yale University Press, 1946), p. 70.

TABLE XII

SUMMARY OF [illegible] DATA

List of Variables

C = The criterion (average grades)
1 = A. C. E.
2 = Cooperative English Test (college form)
3 = High school rank
4 = Otis Self-Administering Tests of Mental Ability
5 = Unit Scales of Attainment-Reading Comprehension
6 = Cooperative English Test (high school form)
7 = Iowa Algebra Aptitude

Intercorrelations

	1	2	3	4	5	6	7
C	.5169	.6591	.7650	.4944	.5062	.4862	.4607
1		.7945	.5033	.8375	.6360	.7258	.7995
2			.6758	.5833	.6686	.8276	.6953
3				.5020	.4957	.5728	.4905
4					.6382	.6457	.6753
5						.7941	.5719
6							.6800

TABLE XIII

SUMMARY OF MEANS (M), STANDARD DEVIATIONS (σ), STANDARD ERRORS OF THE MEANS (σ_M), AND STANDARD ERRORS OF THE STANDARD DEVIATIONS (σ_σ)

List of Variables

C The Criterion (average grades)
1 A. C. E.
2 Cooperative English Test (college form)
3 High school rank
4 Otis Self-Administering Tests of Mental Ability
5 Unit Scales of Attainment-Reading Comprehension
6 Cooperative English Test (high school form)
7 Iowa Algebra Aptitude

	C	1	2	3
σ	.7628	24.31	22.84	64.28
σ_σ	.0853	2.71	2.55	7.18
M	3.1985	109.0250	171.5500	153.5900
σ_M	.2529	8.6192	13.5572	12.1414

	4	5	6	7
σ	9.13	5.31	36.45	13.26
σ_σ	1.02	.59	4.08	1.48
M	46.5949	18.9306	167.2836	60.2127
σ_M	3.6832	1.4966	13.2249	4.7603

CHAPTER V

MULTIPLE CORRELATIONS AND REGRESSION EQUATIONS

In this chapter, the methods and procedures entailed in the determination of multiple coefficients and their subsequent application in the solution of regression equations will be shown. Multiple R's and regression equations will be computed for combinations of the high school variables, college variables, and combined high school and college variables. A comparison of predicted grades and actual grades will be shown.

I. METHODS AND PROCEDURES OF CALCULATING MULTIPLE R FROM COMBINED HIGH SCHOOL AND COLLEGE VARIABLES

Wherry-Doolittle Test Selection Method.[1] Since the majority of methods used to find multiple coefficients of correlations involve overwhelming mechanics of calculation when there are more than three variables, it was necessary in this investigation to employ a technique that was more efficient from the time factor which did not sacrifice accuracy or give a multiple R that would be erroneous or mis-

1 Henry E. Garrett, Statistics in Psychology and Education (New York: Longmans, Green, and Company, 1947), pp. 437-51.

leading. The method chosen for this investigation was the Wherry-Doolittle Test Selection Method which seemed to meet the above qualifications. A brief description of the mechanics and purposes integrated in this method will be found in Appendix A. For a comprehensive description of this method, the reader is directed to that provided by Garrett[2] from which the procedure used in this section of the study was obtained.

This method analytically selects the tests or variables one by one until a maximum multiple R is obtained. Therefore, one is able to obtain a multiple R that is maximum or very nearly maximum through the contributions of a smaller number of variables. The nature of the variables might be such that three or four of the variables would contribute as much towards the multiple R as the combined battery of variables. Those that did not contribute to the magnitude of the coefficient could be discarded. After the selection of each test, or variable, the multiple R at that stage of the process is automatically computed. When this obtained value ceases to increase, the calculation may be halted at that point as selection of any additional variables would be useless. A multiple regression equation may then be computed from this selected battery that will predict the criterion with the highest precision of which the given list of vari-

2 Loc. cit.

ables is capable.

The Problem. This section of the investigation was concerned with the calculation of a multiple R of the highest possible value and the selection of a battery of independent variables that would predict the criterion (average grades) most efficiently. The selection of the independent variables was obtained from a combination of high school and university variables which were as follows: the A. C. E., English Cooperative Test (both high school and college forms), Otis Self-Administering Test of Mental Ability, Unit Scales of Attainment-Reading Comprehension, Iowa Algebra Aptitude, and high school rank. Selection of the battery was made by the Wherry-Doolittle method.

Results. The variables selected (in the order of their selection) were: (1) high school rank which had the highest correlation of all the independent variables with the criterion, .7650, (2) Cooperative English Test (college form) which, in combination with high school rank, gave a multiple R of .7859, (3) Cooperative English Test (high school form) which, in combination with high school rank and Cooperative English Test (college form), gave a multiple R of .7920, (4) Unit Scales of Attainment-Reading Comprehension which, when taken in combination with the above selected variables, brought the multiple R to a value of .8036, and (5) Otis Self-Administering Tests of Mental Ability which, when taken in combination with the previously selected variables, gave

a multiple R of .8042. These correlations have been corrected for chance error by means of the Harry-Doolittle shrinkage formula.

At the termination of the selection process all of the variables, with the exception of the A. C. E. and the Iowa Algebra Aptitude Test, had been selected. The order of selection of the variables and the resulting values of the multiple R obtained after each selection indicated that the bulk of the coefficient was provided by high school rank and that the addition of the other variables when taken in combination did add but very little to the value of the multiple R; the difference being but .0392 (.8042 - .7650). It was obvious that the A. C. E. and the Iowa Algebra Aptitude Test would either add but a very insignificant amount to the multiple R or would actually decrease the obtained value. Also, the order of selection indicated that any combination composed only of high school variables or composed only of university variables would result in a multiple R of less magnitude and, as a result, in less predictive power.

Since the Cooperative English Test (high school form) which was one of the first three selected variables, was administered to the sample of this study during their freshman year in high school, prediction would appear to be feasible on a long range basis. Further insight into the problem of long range prediction will be provided later in this investigation when a multiple R and a regression equa-

tion for a selected combination of high school variables will be calculated and actual and predicted grades will be compared.

To test the significance of the multiple R obtained by the Wherry-Doolittle Test Selection Method, Fisher's test of the significance of R^3 was applied. This method is based on the assumption that the "true R" is actually zero and that the R that was obtained through calculation was not a true R. Before the calculated R can be accepted as being significant, the above assumption must be disproved. This is done by means of probability that an R as large as the one in question could not have been due to sampling errors alone. These probabilities are stated as being at the 5 per cent or the 1 per cent level, which means respectively, that the chances are five in one hundred or one in one hundred that an R as large as the one calculated would arise in other instances. The R, if significant at the 5 per cent level, is spoken of as being "significant"; at the 1 per cent level as being "very significant". These values of significance are obtained from a table.[4] The values listed in the table for significance at the 5 per cent level and the 1 per cent level for N = 80 and number of variables of

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[3] J. P. Guilford, Psycometric Methods, (New York: McGraw-Hill Book Company, Inc., 1936), p.335.

[4] Ibid. p. 549.

five (five tests were selected) are .343 (5 per cent level) and .401 (1 per cent level). These values indicate that a correlation as high as .343 obtained from the data of this investigation could be expected to occur five times in one hundred if the true $\underline{h}$ was zero; that a correlation as high as .401 could be expected to occur one time in one hundred if the true $\underline{h}$ was zero. Since the correlation obtained in this study was .8042 and was much larger than either of the values listed as being significant, the assumption that an $\underline{R}$ as large as the one obtained could be due to sampling errors is disproved as its occurance due to these factors would be much less than one time out of one hundred.

Tests of significance are important as it would be useless to calculate regression equations and apply them to predictions if the obtained $\underline{R}$ was not significant.

Though tests of significance give an indication of whether or not in terms of probability the obtained $\underline{h}$ could be due to the sample, they do not provide a check on mechanical errors. The Cherry-Doolittle method does provide several checks during the process so that any errors can be identified and eliminated, but the writer decided to include a further check by means of a different method of calculation. The method chosen was that of the Horst Technique[5] which is a variation of the Cherry-Doolittle method.

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[5] Paul Horst, "The Discrimination of Two Racial Samples," Psychometrika, Vol. 15, No. 3, September, 1950. pp. 275-288.

In addition to providing a check for errors, this method was used in this investigation to give the writer a working knowledge of its procedures and its overall adaptability to the calculations of multiple coefficients of correlation. The purpose in mind was not to furnish a thorough description of the method. Such a description is much better provided by the author.[6] The procedures as used in this study were obtained from that source and are described in Appendix B.

II. THE MULTIPLE R CHECKED BY MEANS OF THE HORST TECHNIQUE

The Problem. The Horst Technique was used to calculate a multiple R for the criterion with a battery of three variables. These variables were high school rank, Cooperative English Test (high school form), and Cooperative English Test (college form). This battery was selected because it provided the bulk of the multiple R that was obtained through the selection of five variables by the Cherry-Doolittle method. Their order of selection indicated that they would constitute a battery as capable of prediction as a battery composed of the five variables. The multiple R calculated was used as a comparison for that obtained by the Cherry-Doolittle method.

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[6] Loc. cit.

The Results. The multiple R obtained by the Horst Technique was .7979 which compared favorably with that obtained by the Wherry-Doolittle method (.7920) when the shrinkage formula that was applied during the Wherry-Doolittle calculation was taken into consideration. The Horst Technique as part of its procedure also provided a check on the multiple R obtained by that method. This check again confirmed the multiple R. The multiple R obtained by the Wherry-Doolittle method appeared not to have been the result of errors of calculation.

II. METHOD AND PROCEDURE OF CALCULATING A REGRESSION EQUATION FOR SELECTED HIGH SCHOOL AND COLLEGE VARIABLES

Predictions are made possible through the use of regression equations.[7] The regression equations will give the predicted score for the criterion from the obtained scores of one or more variables. Thus it is possible for average grades to be predicted (subject to errors of prediction) from a selected combination of variables. Once the regression equation has been calculated, one need only to substitute the actual scores obtained on each of the variables in the equation, and receive the predicted average grade for that particular student.

In this investigation, a regression equation will be

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[7] Garrett, op. cit., p. 319.

calculated for the selected variables of high school rank, Cooperative English Test (college form), and the Cooperative English Test (high school form). These particular variables were selected to be components of the regression equation on the basis of their selection as the first three variables by the Cherry-Doolittle method. The entire battery of five selected variables could have been used, but it was reasoned that the final two variables selected contributed but very little to the final multiple R and that the first three selected would lend to ease of calculation and adaptability of the regression equation without loss of accuracy.

Procedure. The calculation of a regression equation for variables selected by the Cherry-Doolittle method was not an involved process. The process as given by Garrett[8] required only the use of data obtained during the test selection procedure and the solving of simultaneous equations to obtain the beta weights. The steps involved are given in Appendix C. The beta weights are the coefficients of the regression equation when the scores are given as standard scores. For the purposes of this investigation, the beta weights were converted to b coefficients so that actual or obtained scores could be used in the regression equations.

The beta weights were found to be .5936 for high school rank, .4346 for the Cooperative English Test (college

[8] Ibid., p. 421.

form), and -.2135 for the Cooperative English Test (high school form). These beta weights are indicators of the relative contributions of each variable to the regression equation. High school rank indicated that it was the most important factor, Cooperative English Test (college form) was the next most important, and the Cooperative English Test (high school form) contributed the least amount of the three variables to the regression equation.

The beta weights when converted to $\underline{b}$ weights gave the following values: $\underline{b}_3$ (high school rank) = .0070, $\underline{b}_2$ (Cooperative English Test--college form) = .0145, and $\underline{b}_6$ (Cooperative English Test--high school form) = -.0045.

The regression equation in score form was as follows:

$$X_c = .007X_3 + .0145X_2 - .0045X_6 + .3902.$$

In this equation, $\underline{X}_c$ represents the predicted grade, $\underline{X}_3$ represents the high school rank, $\underline{X}_2$ represents the total English scaled score obtained on the Cooperative English Test (college form), and $\underline{X}_6$ represents the total English raw score obtained on the Cooperative English Test (high school form). To illustrate the use of the regression equation, the scores actually obtained by one of the students of this study will be substituted in the equation and his predicted grade found and compared with the student's actual grade. The data were as follows: high school rank--246, Cooperative English Test (college form) total English scaled score--220, and Cooperative English Test (high school form) total English raw score--

208. The equation after the substitution of the data was as follows:

$$X_c = .007(246) + .0145(220) - .0045(208) + .3902.$$

$$X_c = 4.52.$$

The actual grade received by this student was 4.34.

Predicted grades will not always be so near the actual grade as in the above case. The accuracy with which the average grade may be predicted is given by the standard error of estimate.[9] The standard error of estimate for the regression equation was .4657. This standard error when applied in both a negative and a positive direction to the predicted grade will include the actual grades in two out of three cases. It can be seen from the formula that when R^2 is 1, there will be no error of prediction and the actual grade could be predicted exactly. When R^2 is 0, the standard error is equal to the standard deviation and the regression equation is of no value in predicting grades as each students most probable grade would be the mean. The accuracy of a prediction depends directly upon the standard deviations of the distribution and the degree of correlation between the variables. A summary of the comparisons of predicted grades and actual grades is given in Table XIV, page 71.

[9] Ibid., p. 320.

III. METHODS AND PROCEDURES IN CALCULATING R AND ESTABLISHING REGRESSION EQUATIONS FOR A SELECTED COMBINATION OF HIGH SCHOOL VARIABLES

One of the purposes of this investigation was to provide the staff of the Missoula County High School with a prediction equation that they might be able to use in the guidance of their students. This, of course, would have to come from a combination of variables that are at hand when the counseling and guidance of the student is taking place. A prediction equation that contains variables from the college program would be of no value. For this reason, in this section of the study a regression equation that contains only high school variables will be calculated.

The analysis of the Wherry-Doolittle method showed that two of the high school variables (high school rank and the Cooperative English Test) were two of the first three selected from a combination of all the variables--both college and high school. This would seem to indicate that the high school program does have prediction possibilities. Since the Iowa Algebra Aptitude Test was not selected among the first five variables (out of a total of seven) it would seem that it's possibilities as a predictive factor are limited. For this reason, and to aid in the calculation and the resulting adaptability of the regression equation, the Iowa Algebra Aptitude Test will not be included in the battery of high school variables for which a multiple R and a regression

equation will be calculated.

Procedure. A multiple correlation coefficient for the variables high school rank, Otis Self-Administering Tests of Mental Ability, Unit Scales of Attainment-Reading Comprehension, and the Cooperative English Test (high school form) was calculated by means of the Horst Technique. This method was chosen because of the ease of calculation and because of the factor that the beta weights are computed as a step of the process.

Results. The Horst Technique gave a multiple R, significant at the 1 per cent level, of .7855. This, when compared to the multiple R of the combination of both college and high school selected variables, gives an indication that the combination of high school variables alone are capable of predictions only slightly less valid than those obtained through the combination of selected college and high school variables. This is further brought out by the value of the standard error of estimate which was obtained by the high school variables. The value for the standard error of estimate was .4720. This value is only .0063 greater than the standard error of the combination of selected high school and college variables. For this population at least, long range prediction was possible in terms of probable grades that could be compared favorably with actual grades.

The beta weights were found to be .6896 for high school rank, -.1453 for the Cooperative English Test, .1066

for the Otis Self-Administering Tests of Mental Ability, and .2118 for the Unit Scales of Attainment-Reading Comprehension. Since the beta weights may be used to compare the contributions of the relative variables[10] it was seen that high school rank contributed more than the other variables combined to the prediction of grades; that it contributed about five times as much as the Cooperative English Test, about six times as much as the Otis Self-Administering Tests of Mental Ability, and about three times as much as the Unit Scales of Attainment-Reading Comprehension.

The calculated b coefficients were as follows: .0081 for high school rank, -.0031 for the Cooperative English Test, .0089 for the Otis Self-Administering Tests of Mental Ability, and .0304 for the Unit Scales of Attainment-Reading Comprehension. The value of K (the constant of the regression equation) was found to be 1.4829. The resulting regression equation was as follows:

$$X_c = 1.4829 + .0081X_2 - .0031X_3 + .0089X_4 + .0304X_5$$

where X_2 represents high school rank, X_3 represents the English Cooperative Test, X_4 represents the Otis Self-Administering Tests of Mental Ability, and X_5 represents the Unit Scales of Attainment-Reading Comprehension.

When the above regression equation was applied to the scores obtained by the same student whose grade was predicted

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[10] Guilford, op. cit., p. 382.

by the regression equation in the previous section, the predicted grade compared favorably with the actual grade. The data was as follows: high school rank--246, English Cooperative Test--208, Otis Self-Administering Tests of Mental Ability--62, and Unit Scales of Attainment-Reading Comprehension--30. The formula was as follows:

$$\bar{X}_c = 1.4829 + .0081(246) - .0031(208) + .0089(62) + .0304(30)$$

$$\bar{X}_c = 4.29 \pm .4720 \text{ (standard error of estimate).}$$

The actual grade obtained by this student was 4.34.

The predicted grade for this student by means of the regression equation of combined high school and college variables was $4.52 \pm .4657$. For this student the high school prediction was .05 grade below the actual grade and the combined high school and college prediction was .18 grade above the actual grade. This does not mean that the high school variables will be consistently better predictors in all cases than the combination of high school and college variables. It is only true for this one particular student.

A summary of predicted grades and actual grades for the high school battery will be found in Table XIV, page 71.

IV. METHODS AND PROCEDURES OF CALCULATING R AND ESTABLISHING A REGRESSION EQUATION FOR A SELECTED COMBINATION OF COLLEGE VARIABLES

Another purpose of this investigation was to provide the staff of the counseling center at the University with an evaluation of, and a regression equation for, their testing

program. This had the purpose in mind of aiding them in the guidance of students that enter Montana State University from the Missoula County High School. There were only two of the variables of this study from the college testing program and they were the A. C. E. and the Cooperative English Test (college form). An analysis of the Wherry-Doolittle method showed that in all probability these two tests would comprise a battery that would have the least predictive value of the three combinations chosen for this investigation. The A. C. E. was not selected among the first five variables selected by the Wherry-Doolittle method, and though the Cooperative English Test was, the largest share of the predictive value of the regression equation (as seen by the beta weights) of the combination of high school and college variables was contributed by high school rank.

Procedure. Since the calculations involved in a two variable problem are relatively simple, the multiple R was calculated by formula. The formula, as given by Guilford[11], is as follows:

$$R_{1.23} = \sqrt{\beta_{12.3}\, r_{12} + \beta_{13.2}\, r_{13}}$$

and $$\beta_{12.3} = \frac{r_{12} - r_{13}\, r_{23}}{1 - r_{23}^2}$$

and $$\beta_{13.2} = \frac{r_{13} - r_{12}\, r_{23}}{1 - r_{23}^2}$$

[11] Guilford, op. cit. pp. 381-384.

In the above formula, 1 is the criterion, 2 is the A. C. E., 3 is the English Cooperative Test, r_{12} is the correlation of grades with the A. C. E. (.5169), r_{13} is the correlation of grades with the Cooperative English Test (.6591), and r_{23} is the correlation of the A. C. E. with the Cooperative English Test. Calculation of the beta weights revealed that the beta weight for the Cooperative English Test was .6735, while that of the A. C. E. was -.0183. This would indicate that the effect of the Cooperative English Test as a predictive factor in the regression equation is much greater than that of the A. C. E. The calculation of the multiple R gave a value, which was significant at the 1 per cent level, of .6591, the lowest of any of the three combinations that have been investigated in this study. This correlation is exactly equal to that of the Cooperative English Test with the criterion. Obviously, the A. C. E. has contributed nothing to the multiple R obtained.

To provide a check on the calculations and also to determine if the Horst Technique could be applied to a three variable problem, it was used to calculate the multiple R and the beta weights. The process was exceedingly simple and an R of .6592 was calculated. This R is only .0001 different than that calculated by means of the formula. The beta weights given by the Horst Technique were -.0180 (only different from the formula beta weights by .0002), and .6735 which was identical to the one obtained by formula. The

Horst Technique appears to be readily adaptable to a three variable problem and is by far the easiest method of calculation the writer has encountered.

The b coefficients were calculated and were A. C. E. -.0006, and Cooperative English Test .0225. The constant K was equal to -.5861 and the standard error of estimate was .5737, the largest error of estimate of the three combinations studied. The regression equation was as follows:

$$\overline{X}_c = -.5861 - .006X_2 + .0225X_3.$$

In the above formula, X_2 refers to scores on the A.C.E. and X_3 refers to scores on the Cooperative English Test. Scores for the A. C. E. are total raw scores and those of the Cooperative English Test are total English scaled scores.

The data for the same student whose scores were entered in the previously determined regression equations was A. C. E. --170 and Cooperative English Test--220. After substitution in the equation, it read as follows:

$\overline{X}_c = -.5861 - .0006(170) + .0225(220)$, and $\overline{X}_c = 4.45 + .5737$. This predicted grade is .11 higher than the actual grade.

A summary of predicted grades by means of the regression equation for the college variables is given in Table XIV.

The college battery, as was suspected, was the least valid of any of the regression equations determined by this study. There is some doubt that it would be an acceptable predictor, but at the very least it is much better than mere subjective evaluation of a student's probable success.

TABLE XIV

A COMPARISON OF ACTUAL AND PREDICTED GRADES
OF THIRTY-FIVE STUDENTS TAKEN
HELP ATTENDICALLY FROM THE SAMPLE

Actual Grade	Predicted Grade (High School and College Factors)	σ est	Predicted Grade (College Factors)	σ est	Predicted Grade (High School Factors)	σ est
3.73	3.71	.4657	3.65	.5737	3.45	.4720
2.60	2.89		3.34		2.78	
4.07	4.10		4.18		3.96	
3.18	3.16		2.99		3.47	
3.58	3.54		3.10		3.58	
3.64	[3.05]		3.30		[3.13]	
4.52	4.24		4.41		4.27	
3.77	3.86		3.60		3.69	
2.55	[3.19]		3.05		[3.25]	
2.99	3.36		3.40		3.46	
3.11	2.99		3.19		2.99	
3.27	3.67		3.81		3.51	
3.37	3.36		3.23		3.31	
3.13	3.24		3.52		3.04	
4.39	3.99		4.04		4.32	
4.11	4.00		3.69		4.15	
2.93	[3.46]		2.90		[3.52]	
3.30	3.67		3.71		3.45	
3.50	[1.75]		[2.16]		[2.21]	
3.16	3.51		3.58		3.53	
4.68	[3.87]		[3.96]		[3.78]	
1.75	2.85		3.18		2.93	
2.91	2.78		3.03		3.14	
3.28	3.47		3.62		3.12	
2.95	2.95		3.49		2.96	
4.80	[4.23]		4.75		[4.29]	
3.71	3.92		[4.31]		3.67	
2.95	2.73		3.80		2.50	
3.66	3.70		3.74		3.92	
1.94	2.35		[3.07]		2.28	
2.54	2.79		3.58		2.66	
3.43	3.24		3.49		3.52	
4.29	3.65		[3.25]		[3.71]	
1.36	1.67		[2.40]		1.91	
4.45	[3.80]		[3.87]		[3.81]	

* Circled grades do not fall within the error of estimate (σ est).

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study was (1) to evaluate the Otis Self-Administering Tests of Mental Ability, the Unit Scales of Attainment-Reading Comprehension, the Cooperative English Test, and the Iowa Algebra Aptitude Test administered to freshman classes at the Missoula County High School, plus high school graduation rank as factors related to the prediction of academic success; (2) to evaluate the American Council on Education Psychological Test and the Cooperative English Test administered to entering freshmen at Montana State University as factors related to the prediction of academic success; (3) to determine the highest possible multiple correlation of selected factors of variables obtained from both the university and high school programs as listed above; and (4) to compute multiple regression equations for 1, 2, and 3 above.

The criterion was first year grade point average obtained from studies at Montana State University by eighty graduates of the class of 1952 of the Missoula County High School.

No attempt was made to develop prediction equations for the various subject matter fields.

Techniques. Two methods formed the basis of the calculations of the multiple coefficients of correlation. These methods were the Wherry-Doolittle Test Selection Method and the Horst Technique.

Results. The highest multiple R was obtained through a battery of the English Cooperative Test (both high school and college forms), high school rank, Unit Scales of Attainment-Reading Comprehension, and the Otis Self-Administering Tests of Mental Ability. This correlation was .8042. A regression equation was calculated for the three independent variables that contributed to the bulk of this correlation and the beta coefficients gave the indication that high school rank was the most important factor, the Cooperative English Test (college form) the next, and the Cooperative English Test (high school form) contributed the least.

A battery of independent variables from the high school program composed of high school rank, Cooperative English Test, Otis Self-Administering Tests of Mental Ability, and the Unit Scales of Attainment yielded a multiple R of .7855. The Iowa Algebra Aptitude Test was not placed in this battery because the Wherry-Doolittle method indicated that it would not be a contributing factor. A regression equation was calculated and the beta coefficients indicated that high school rank contributed very highly, the Unit Scales of Attainment about one third as much as high school rank, and the others to a lesser degree.

A battery composed of university variables (the A.C.E. and the Cooperative English Test) yielded a multiple R of .6591, which was the lowest of the three batteries used in this investigation. A regression equation and the beta coefficients indicated that the Cooperative English Test was practically the sole contributor to predictions.

Need for Further Research. (1) A need exists for the application of the regression equations calculated in this study to be applied to other graduates of the Missoula County High School so that their validity as predictors can be ascertained.

(2) The prediction of success should be put on a differential basis as soon as possible. In order to individualize students' programs so that they can make the greatest use of their particular interests, aptitudes, and previous attainments, it is essential to have some estimate of their probable achievement in different courses of curriculums.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Aaron, Sadie, "The Predictive Value of Cumulative Test Results," Stanford University Bulletin, Eighth Series, No. 3 Stanford, California: Stanford University, November 29, 1947. 159 pp.

2. Angell, M. A., Langton, K. C., Meyer, G. A., and Pettit, M. L., "An Evaluation of General and Specific Admission Requirements at the University of Washington." Unpublished Doctor's Dissertation, University of Washington, Seattle, 1950. 431 pp.

3. Bear, Robert M., "The Predictive Value of the Iowa Physics Aptitude Placement Test," Journal of Applied Psychology, 11:383-84, October, 1927.

4. Berdie, Ralph F., "The Prediction of College Achievement and Satisfaction," Journal of Applied Psychology, 28:239-45, June, 1944.

5. _____, Information on a Mimeographed Sheet as Supplement to an Address Given to the National Vocational Guidance Convention, Chicago, March 25, 1951.

6. Bernreuter, R. G. and Goodman, C. H., "A Study of the Thurstone Primary Mental Abilities Tests," Journal of Applied Psychology, 32:55-56, February, 1941.

7. Bird, Charles, and Bird, D., Learning More by Effective Study. New York: D. Appleton-Century Company, Inc., 1945. 275 pp.

8. Borg, Walter R., "A Study of the Relationship Between General Intelligence and Success in Art College," Journal of Education Psychology, 40:434-440, November, 1949.

9. Brown, H. S., "Differential Prediction by the A. C. E.," Journal of Education Research, 44:110-121, October, 1950.

10. Brush, E. N., "Mechanical Ability as a Factor in Engineering Aptitude," Journal of Applied Psychology, 25:300-12, June, 1941.

11. Buckton, L., and Doppelt, J. E., "Use of Selection Test at Brooklyn College," Occupations, 28:357-60, March, 1950.

12. Buros, Oscar K., The Nineteen Fortieth Mental Measurements Yearbook. Highland Park, New Jersey: Mental Measurements Yearbook, 1941. 1237 pp.

13. _____, The Third Mental Measurements Yearbook. New Brunswick: Rutgers University Press, 1949. 1047 pp.

14. Butsch, R. L. C., "Improving the Prediction of Academic Success Through Differential Weighting," Journal of Education Psychology, 30:401-420, September, 1939.

15. Byrns, Ruth K., "Scholastic Aptitude and Freshman Achievement," School and Society, 35:713-18, May 21, 1932.

16. Cochran, S. W., and Davis, F. S., "Predicting Freshman Grades at George Peabody College for Teachers," Peabody Journal of Education, 27:352-6, May, 1950.

17. Crawford, A. B., "Forecasting Freshman Achievement," School and Society, 31:125-130, January 25, 1930.

18. _____, and Burnham, P. S., Forecasting College Achievement, New Haven: Yale University Press, 1946. 241 pp.

19. Crowley, Joseph R., "An Evaluation of the American Council on Education Psychological Examination and the Cooperative English Test as Guidance Instruments at Montana State University." Unpublished Master's Thesis, Montana State University, Missoula, 1951. 140 pp.

20. Diederich, Paul B., "The Abolition of Subject Requirements for Admission to the College," School Review, 57:364-70, September, 1949.

21. Douglass, Harl R., "Selecting College Entrants," Journal of Higher Education, 3:179-84, April, 1932.

22. _____, "Different Levels and Patterns of Ability Necessary for Success in College," Occupations, 22:182-86, 1943.

23. Durflinger, G. W., "The Prediction of College Success: A Summary of Recent Findings," American Association of College Registrars Journal, 19:66-78, October, 1943.

24. Edds, J. H., and McCall, W. A., "Predicting the Scholastic Success of College Freshman," Journal of Education Research, 27:127-30, October, 1933.

25. Edwards, Allen L., Statistical Analysis for Students in Psychology and Education. New York: Rinehart and Company, Inc., 1946. 360 pp.

26. Eells, Walter, "Developments in Higher Education--'Wise and Otherwise,'" American Association of Collegiate Registrars Journal, 17:455-92, July, 1942.

27. Ficken, C. E., "Predicting Achievement in the Liberal Arts College," School and Society, 42:518-20, 1935.

28. Foley, Andrew W. and Folsom, Willys W., "A Validation Study of the American Council on Education Psychological Examinations as a Guidance Tool." Unpublished Master's Thesis, University of Washington, Seattle, 1947. 70 pp.

29. Froehlich, C. J., "Academic Predictions at the University of Wisconsin," American Association of Collegiate Registrar's Journal, 17:65-79, October, 1941.

30. Garrett, Henry E., Statistics in Psychology and Education. New York: Longmans, Green, and Company, 1947. 487 pp.

31. Garrett, H. L., "Predicting College Success Upon the Basis of High School Records," Peabody Journal of Education, 11:193-201, March, 1934.

32. G. A. T. B. Senior Project Staff, et al., "General Aptitude Test Battery Patterns for College Areas," Occupations, 29:518-26, April, 1951.

33. Gilkey, Royal, "The Relation of Success in Certain Subjects in High School to Success in the Same Subjects in College," School Review, 37:576-88, October, 1929.

34. Guilford, J. P., Psychometric Methods. New York: McGraw-Hill Book Company, Inc., 1936. 566 pp.

35. Hartson, L. D., and Sorow, A. J., "The Value of Intelligence Quotients Obtained in Secondary Schools for Predicting College Scholarship," Education and Psychological Measures, 1:387-98, Autumn, 1941.

36. Hass, Leonard, "Four Year Studies of the Freshman Classes 1936 and 140 Eau Claire State Teachers' College," Journal of Education Research, 42:54-61, September, 1948.

37. Hepner, Walter A., "Factors Underlying Unpredicted Scholastic Achievement of College Freshmen," Journal of Experimental Education, 7:159-98, March, 1939.

38. Humber, W. J., "The Relationship Between Reading Efficiency and Academic Success in Selected University Curricula." Journal of Education Psychology, 35:17-26, January, 1944.

39. Johnson, A. P., The Prediction of Scholastic Achievement For Freshman Engineering Students at Purdue University. Purdue University Studies in Higher Education, XLIV, West Lafayette, Indiana, 1942. 24 pp.

40. Jordan, F. M., "Some Results and Correlation of Army Alpha Tests," School and Society, 11:354-58, May 29, 1920.

41. Kandel, J. L., "Prolonging Infancy," School and Society, 72:91-2, August, 1950.

42. Lanigan, Mary A., "The Effectiveness of the Otis, The A.C.E., and the Minnesota Speed of Reading Tests for Predicting Success in College," Journal of Education Research, 48:289-91, December, 1947.

43. Lauer, A. R., and Evens, J. F., "The Relative Predictive Value of Different High School Subjects on College Grades," School and Society, 31:159-60, February 1, 1930.

44. Laycock, S. R., and Hutcheon, N. B., "A Preliminary Investigation Into the Problem of Measuring Engineering Aptitude," Journal of Education Psychology, 30:280-89, April, 1939.

45. Leaf, C. T., "Prediction of College Marks," Journal of Experimental Education, 8:303, March, 1940.

46. Leonard, J. Paul, "Can We Face the Evidence on College Entrance Requirements?" School Review, 53:327-35, June, 1945.

47. Lins, L. J., "Probability Approach to Forecasting University Success with Measured Grades as the Criterion," Educational and Psychological Measurements, 10, No. 3:386-91, Spring, 1951.

48. Lord, F., Conlies, J. T., and Cynamon, M., "The Pre-engineering Inventory as a Predictor of Success in Engineering College," Journal of Applied Psychology, 34:30-39, February, 1950.

49. Martin, R. M., "Predicting Success in College," Education, 62:52-58, September, 1941.

50. May, Mark A., "Predicted Academic Success," Journal of Education Psychology, 14:429-40, October, 1923.

51. McClanahan, Walter R., and Morgan, David H., "Use of Standardized Tests in Counselling Engineering Students in College," Journal of Education Psychology, 39:491-501, December, 1948.

52. McGehee, W., "The Prediction of Differential Achievement in A Technological College," Journal of Applied Psychology, 27:88-92, February, 1943.

53. Meyer, P. C., and Schultz, D. G., "Predicting Academic Achievement with a New Aptitude Interest Questionnaire," Education and Psychological Measurements, 10; 4:654-63, Fall, 1950.

54. Moore, Marjorie C., "Evaluation of Certain Factors for the Prediction of Success of Students Entering the College of Pharmacy of the University of Minnesota From 1933 Through 1943; Summary of a Thesis," Journal of Experimental Education, 14:207-24, March, 1946.

55. Nelson, M. J., "Some Data From Freshmen Test," School and Society, 31:772-774, June 7, 1930.

56. Odell, Charles W., "Attempts at Predicting Success in the Freshman Year at College," School and Society, 25: 702-06, June 11, 1927.

57. _____, An Introduction to Educational Statistics. New York: Prentice-Hall, Inc., 1946. 269 pp.

58. Pierson, George A., "School Marks and Success in Engineering," Education and Psychological Measurement, 7:612-13, Autumn, Part II, 1947.

59. Quaid, T. O. D., "A Study in the Prediction of College Freshmen Marks," Journal of Experimental Education, 6:363, March, 1938.

60. Reed, Cecil R., "The Prediction of Scholastic Success in a Municipal University," School and Society, 48:187-88, August 6, 1938.

61. Reitz, Wilhelm, "Forecasting Marks of New Plan Students at the University of Chicago," School Review, 43: 34-48, January, 1935.

62. Root, W. T., "The Freshman: Thorndike College Entrance Tests, First Semester Grades, Benet Tests," Journal of Applied Psychology, 7:77-92, May, 1923.

63. Salley, Ruth E., and Heintraub, Ruth G., "Student Records of Entrance and Graduation," School and Society, 69:404-06, June 4, 1949.

64. Seppenfield, R. H., "Prediction of College Scholarships for Groups Having Effort Indices of Restricted Range," Journal of Applied Psychology, 27:448-51, October, 1943.

65. Schmitz, S. B., "Predicting Success in College: A Study of Various Criteria," Journal of Education Psychology, 28:465-473, September, 1937.

66. Seagel, David, "Predictions of Success in College," United States Department of the Interior, Office of Education Bulletin No. 15. Washington, D. C., United States Government Printing Office, 1934. 98 pp.

67. _____, David, and Proffitt, Maris M., Some Factors in the Adjustment of College Students, United States Department of the Interior, Office of Education Bulletin No. 12, Washington, D. C.: United States Printing Office, 1937. 49 pp.

68. Stone, Charles L., "The Significance of Alpha in College," Journal of Education Psychology, 13:289, May, 1922.

69. Stuit, Dewey B., and Hudson, Harry M., "The Relationship of Primary Mental Abilities to Scholastic Success in Professional Schools," Journal of Experimental Education, 10:179-82, March, 1942.

70. _____, Dickson, G. E., Jordan, T. E., and Schloerb, L., Predicting Success in Professional Schools. American Council on Education Studies, Menasha, Wisconsin: George Banta Publishing Company, 1948. 127 pp.

71. Super, Donald E., Appraising Vocational Fitness. New York: Harper and Brothers, 1949. 727 pp.

72. Terman, Lewis M., "Intelligence Tests in Colleges and Universities," School and Society, 13:481-94, April, 1921.

73. Thompson, Grace M., "College Grades and the Group Rorschach," Journal of Applied Psychology, 32:399-406, August, 1948.

74. Thurstone, T. T., and Thurstone, T. G., "The 1930 Psychological Examination," Educational Record, 12:169-78, April, 1931.

75. Traver, R. M. W., "Predictions of Achievement," School and Society, 61:107-108, February 17, 1945.

76. Votaw, D. F., "Comparison of Test Scores of entering Freshmen as Instruments for Predicting Subsequent Scholarship," Journal of Education Research, 40: 215-18, November, 1946.

77. Wagner, Hazie B., and Straubel, Eunice, "Predicting Performance in College English," Journal of Educational Research, 30:694-98, May, 1937.

78. Wallace, W. P., "Differential Predictive Value of the A. C. E. Psychological Examination," School and Society, 7:23-25, July 9, 1949.

79. Williamson, E. G., "The Decreasing Accuracy of Scholastic Prediction," Journal of Education Psychology, 28:1-16, January, 1937.

APPENDIX

APPENDIX A

METHOD AND PROCEDURE OF COLLECTING KEY ITEMS OF THE WHERRY-DOLITTLE TEST SELECTION METHOD

Procedure. Step 1. Worksheets like those of Worksheet I, Worksheet II, and Worksheet III were drawn up and the intercorrelations of the variables and the criterion were entered in Worksheet I.

Step 2. The correlations of the criterion with each of the variables listed in Worksheet I were entered with the signs reversed in the V_1 row of Worksheet II. The numbers heading the columns refer to the variables and follow the system of numbering that was established in Worksheet I.

Step 3. In each column of the Z_1 row in Worksheet III the number 1.0000 was inserted.

Step 4. The $\frac{V_1^2}{Z_1}$ quotients for each of the corresponding columns of Worksheets II and III were calculated in turn and the one having the highest value was then selected as the first variable. In this problem, the highest quotient was obtained from column 3 which represents high school rank. This highest value obtained was .5852.

Step. 5 In this step, the Wherry shrinkage formula

$$\bar{R}^2 = 1 - K^2 \frac{(N - 1)}{(N - m)}$$

was applied. $\bar{R}$ represents the "shrunken" multiple correlation coefficient from which chance error has been removed. This $\underline{R}$ was calculated in a systematic manner as follows:

Step 4. The $\frac{V_1^2}{Z_1}$ quotients for each of the corresponding columns of Worksheets II and III were calculated in turn and the one having the highest value was then selected as the first variable. In this problem the highest quotient was obtained from column 3 which represents high school rank. This highest value obtained was .5852.

Step 5. In this step the Wherry shrinkage formula

$$\bar{R}^2 = 1 - K^2 \frac{(N - 1)}{(N - m)}$$

was applied. $\bar{R}$ represents the "shrunken multiple correlation coefficient from which chance error has been removed. This $\underline{R}$ was calculated in a systematic manner as follows:

1. A work sheet similar to Worksheet IV was prepared.

2. 1.0000 was entered in column c, row 2, and N = 80 was entered in column d.

3. The quotient $\frac{V_1^2}{Z_1}$ was entered in column b, row 1.

As was shown in Step 4, $\frac{V_1^2}{Z_1} = \frac{(-.7650)^2}{1.0000} = .5852.$

WORKSHEET NO. 1

HENRY-DOOLITTLE METHOD

List of Variables

C. The criterion (average grades)
1. A.C.E.
2. Cooperative English Test (college form)
3. High school rank
4. Otis Self-Administering Tests of Mental Ability
5. Unit Scales of Attainment-Reading Comprehension
6. Cooperative English Test (high school form)
7. Iowa Algebra Aptitude Test

Intercorrelations

	1	2	3	4	5	6	7
C	.5169	.6591	.7650	.4944	.5062	.4062	.4607
1.	1.0000	.7945	.5033	.3375	.6360	.7258	.7995
2.		1.0000	.6758	.5833	.6686	.8276	.6953
3.			1.0000	.5020	.4957	.5728	.4905
4.				1.0000	.6382	.6457	.6753
5.					1.0000	.7941	.5719
6.						1.0000	.6000
7.							1.0000

WORKSHEET NO. II

MERRY-DOOLITTLE METHOD

	1	2	3	4	5	6	7
v_1	-.5169	-.6591	-.7650	-.4944	-.5062	-.4862	-.4607
v_2	-.1319	-.1421		-.1104	-.1270	-.0430	-.0355
v_3	-.0130			-.0466	-.0393	.0672	.0097
v_4	-.0278			-.0809	-.0910		-.0125
v_5	-.0142			-.0513			-.0060

WORKSHEET NO. III

WHERRY-DOOLITTLE METHOD

	1	2	3	4	5	6	7
z_1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
z_2	.7467	.5433		.7480	.7543	.6719	.7594
z_3	.3666			.6384	.5495	.3147	.5158
z_4	.3514			.5566	.3669		.4314
z_5	.3432			.5190			.4795

WORKSHEET NO. IV

MURRY-DOOLITTLE METHOD

a	b	c	d	e	f	g	
	$\frac{V_{x1}^2}{Z_{x1}}$	K^2	$\frac{N-1}{N-m}$	$\overline{K}^2$	$\overline{R}^2$	$\overline{R}$	Test #
0.		1.0000	N = 80				
1.	.5852	.4148	1.0000	.4148	.5852	.7650	3
2.	.0372	.3776	1.0128	.3824	.6176	.7859	2
3.	.0143	.3633	1.0260	.3727	.6273	.7920	6
4.	.0226	.3407	1.0395	.3542	.6458	.8036	5
5.	.0052	.3355	1.0533	.3533	.6467	.8042	4

4. .5852 was subtracted from 1.0000 (the c entry in the O row) to obtain .4148 which was entered in column c, row 1.

5. The quotient (N - 1) ÷ (N - m) was found and entered in column d, row 1. (N -1) equals 79; and since m (the number of tests selected) is 1, (N - m) also equals 79. Their quotient is equal to 1.0000.

6. The product of columns c and d was entered in column e: .4148 X 1.0000 = .4148.

7. The column e was subtracted from 1.0000 and entered in column f, row 1. This value, $\bar{R}^2$, is the square of the shrunken multiple correlation coefficient and was equal to .5852.

8. The square root of the column f entry was calculated and entered in column g, row 1. This entry was .7650, and was the correlation of Variable 3 with the criterion.

Step 6. To aid in the selection of a second test that was to be added to our battery of one, a work sheet similar to that which is shown in Worksheet V was prepared. Calculations in Worksheet V were as follows:

1. The a_1 row was left blank.

2. The correlations of Variable 3 (the first selected variable) with each of the other variables WorksheetI were entered in row b_1. These r's were .5033, .3758, .5020, .4957, .5728, and .4905. 1.0000 was entered in the column for Variable 3. The correlation of Variable 3 with the criterion was

WORKSHEET NO. V

WHERRY-DOOLITTLE METHOD

	1	2	3	4	5	6	7	-C	Check Sum	Selected Variable
a_1										
b_1	.5033	.6758	1.0000	.5020	.4957	.5728	.4905	-.7650	3.4751	3
c_1	-.5033	-.6758	-1.0000	-.5020	-.4957	-.5728	-.4905	.7650	-3.4751	
a_2	.7945	1.0000	.6753	.5033	.6686	.3276	.6953	-.6591	4.5860	2
b_2	.4544	.5433		.2440	.3336	.4405	.3630	-.1421	2.2375	
c_2	-.3364	-1.0000		-.4491	-.6140	-.8108	-.6696	.2615	-4.1103	
a_3	.7250	.3276	.5728	.6457	.[illegible]741	1.0000	.6100	-.4362	4.7593	6
b_3	.0691			.1604	.2397	.3147	.1040	.0672	.9551	
c_3	-.2196			-.5097	-.7617	-1.0000	-.3305	-.2135	-3.0349	
a_4	.6360	.6686	.4957	.6332	1.0000	.7941	.5719	-.5062	4.2903	5
b_4	.0549			.1174	.3669		.0262	-.0910	.4744	
c_4	-.1496			-.3200	-1.0000		-.0714	.2430	-1.2930	

entered with the sign reversed in column -C.

3. The algebraic sum of the b_1 entries was written in the "Check Sum" column. This sum was 3.4751.

4. Each b_1 entry was multiplied by the negative reciprocal of the b_1 entry for Variable 3, the first selected variable. These products were entered in the c_1 row. Since the negative reciprocal of Variable 3's b_1 entry was -1.0000, the b_1 entries are entered in the c_1 row with the signs reversed.

Step 7. A vertical line was drawn under Variable 3 in Worksheets II and III to show that it had been selected. A second variable was selected as follows:

1. To each V_1 entry in Worksheet II was added algebraically the product of the b_1 entry in the criterion (-C) column of Worksheet V by the c_1 entry for each of the other tests. The results were entered in the V_2 row. The formula for V_2 is $V_2 = V_1 + b_1$ (criterion) $\times c_1$ (each test).

Step 8. The test that had the largest $\frac{V_2^2}{Z_2}$ quotient was selected as the second variable for our battery. The quantity $\frac{V_2^2}{Z_2}$ is a measure of the amount which the second variable contributes to the squared multiple correlation coefficient, R^2. From Worksheets II and III it was found that

Variable 2 had the largest $\frac{V_2^2}{Z_2}$ quotient $\frac{(-.1421)^2}{.5433} = .0372$.

Step 9. The new multiple correlation coefficient when Variable 2 is added to Variable 3 was calculated as follows:

1. The quantity .0372 $\left(\frac{V_2^2}{Z_2}\right)$ was entered in column b, row 2 of Worksheet IV.

2. The ratio $\frac{V_2^2}{Z_2}$ was subtracted from the K^2 entry in column c, row 1, and the results were entered in column c, row 2. For the entry in column c, row 2, the computation was .4148 -.0372 = .3776.

3. The quotient $\frac{(N - 1)}{(N - m)}$ was next found. Since N = 80 and m (the number of variable chosen) equals two, we had 79 ÷ 78 = 1.0128 for the column d, row 2 entry.

4. The product of the c and d columns was recorded in column e.

5. The column e entry was subtracted from 1.0000 and gave .6176 for the entry in column f, row 2.

6. The square root of .6176 was computed and entered in column g. This is the multiple coefficient $\bar{R}$ corrected for chance errors. It was clear that by adding Variable 2 to Variable 3 that the multiple $\bar{R}$ was increased from .7650 to

.7859 which was a quite small increase.

Step 10. Since $\underline{R}$ for Variables 2 and 3 was larger than the correlation for Variable 3 alone, the process was continued for a third variable with the hope that the multiple $\underline{R}$ would be increased.

Step 11. Worksheet V was returned to and $\underline{a}_2$, $\underline{b}_2$, and c_2 were calculated. The process was as follows:

1. The correlation coefficient of the second selected variable with each of the other variables and with the criterion were recorded in the $\underline{a}_2$ row. The correlation of Variable 2 with the criterion was entered with the sign reversed in the -C column.

2. The algebraic sum of the $\underline{a}_2$ entries was entered in the Check Sum column.

3. A vertical line was drawn down through the $\underline{b}_2$ and $\underline{c}_2$ for Variable 3, the first selected variable, to indicate that it had previously been selected.

4. The $\underline{b}_2$ entries for each variable were computed by adding to the $\underline{a}_2$ entry the product of the $\underline{b}_1$ entry of the given variable by the $\underline{c}_1$ entry of the second selected variable. The formula is $\underline{b}_2 = \underline{a}_2 + \underline{b}_1$ (given variable) X $\underline{c}_1$ (second selected variable). The $\underline{b}_2$ entries for the criterion and Check Sum column were computed in the same manner.

5. There were three checks for the $\underline{b}_2$ row. First, the entry for the second selected variable (2) should equal the $\underline{Z}_2$ entry for the same variable in Worksheet III. Both

entries were .5433. Second, the entry in the criterion column should equal the $\underline{V}_2$ entry of the second selected variable in Worksheet II. Both entries were -.1421. Third, the entry in the Check Sum column should equal the sum of all of the entries in the $\underline{b}_2$ row. Both entries coincided.

6. Each $\underline{b}_2$ entry was multipled by the negative reciprocal of the $\underline{b}_2$ entry of the second selected variable (Variable 2) and the results were recorded in the $\underline{c}_2$ row.

7. There were three checks for the $\underline{c}_2$ entries. First, the $\underline{c}_2$ row entry of the second selected variable should be -1.0000; it was. Second, the $\underline{c}_2$ entry in the Check Sum column should equal the sum of all c_2 entries; they did. Third, the product of the $\underline{b}_2$ and c_2 entries in the criterion column should equal the quotient $V_2^2 \div {}_2$ in column b, row 2 of Worksheet IV in absolute value. .0372 equalled -.0372 in absolute value.

Step 12. A vertical line was drawn under Variable 2 in Worksheets II and III to indicate that it had been selected as the second variable. In order to select a third variable, $\underline{V}_3$ and $\underline{Z}_3$ were calculated in a manner analogous to Step 7. The formula for $\underline{V}_3$ is $V_3 = V_2 \not / \underline{b}_2$ (of the criterion) $\times c_2$ (each variable). The formula for Z_3 is $Z_3 = Z_2 \not / \underline{b}_2$ (for a given test) $\times c_2$ (the same test). The third selected test was that one which had the largest $V_3^2 \div Z_3$ quotient from Worksheets II and III. This was variable 6 for which the value of the above quotient was .0143.

Step 13. The obtained quotient .0143 was entered in column b, row 3, of Worksheet IV and the procedure of Step 9 was followed in order to obtain a new R of .7920. This multiple coefficient of correlation is but very slightly larger than that obtained when Variable 3 and Variable 2 are operating together. This would seem to indicate that high school rank alone will furnish nearly all of the multiple coefficient of correlation's magnitude and that any combination of the other factors when taken in addition will contribute but very slightly. The process could have been halted at this point because it was evident that any additional variables selected would add but very little to the predictive value of a regression equation. However, it was desired to determine in what order the other variables of the study would be selected so as to gain some insight into their values as predictive factors.

Variable 6 was included in the battery and the procedure for the selection of a fourth variable was undertaken.

Step 14. The process involved in the calculations of a_3, b_3, and c_3 was similar to that of Step 11. The a_3 entries were the correlations of Variable 2 with each of the other variables including the criterion. The correlation of Variable 2 with the criterion was entered in the -C column as a negative value.

1. The formula for b_3 is $b_3 = a_3 - b_1$ (a given variable) $\times$ c_1 (of the third selected variable) $- b_2$ (given

variable) $\times$ $\underline{c}_2$ (third selected variable).

There are three checks for the $\underline{b}_3$ entries. First, the $\underline{b}_3$ entry for the third selected variable should equal the $\underline{Z}_3$ entry for Variable 6 in Worksheet III. Both values were .3147. Second, the entry in the criterion column should equal the $\underline{V}_3$ of the third selected variable. Both values were .0672. Third, the Check Sum entry should equal the sum of all the other entries in the $\underline{b}_3$ row. For this problem, .9551 equaled .9551.

2. The formula for $\underline{c}_3$ is $\underline{b}_3$ X the negative reciprocal of the $\underline{b}_3$ entry for the third selected variable (Variable 6). The negative reciprocal of the $\underline{b}_3$ entry (.3147) was -3.1776. The entries for the $\underline{c}_3$ row may be checked in a manner like Step 11. First, the $\underline{c}_3$ row entry of the third selected variable (Variable 6) should be -1.0000. -1.0000 was the entry in the $\underline{c}_3$ row of Variable 6 for this problem. Second, the $\underline{c}_3$ entry in the Check Sum column should equal the sum of the $\underline{c}_3$ row. Both values were -3.0349. Third, the product of the $\underline{b}_3$ and the $\underline{c}_3$ entries in the criterion column should equal the quotient $\underline{V}_3^2 \div \underline{Z}_3$ in absolute value. These values were both equal in absolute value as they were .0143 and -.0143.

Step 15. $\underline{V}_4$ and $\underline{Z}_4$ were found in a manner similar to that of Step 12. The formula for $\underline{V}_4$ is $\underline{V}_4 = \underline{V}_3 \times \underline{b}_3$ (of the criterion) $\times$ $\underline{c}_3$ (of each variable). The formula for $\underline{Z}_4$ is $\underline{Z}_4 = \underline{Z}_3 \times \underline{b}_3$ (a given variable) $\times$ $\underline{c}_3$ (the same variable).

The quotient, $V_4^2 \div Z_4$ was then calculated and a fourth variable was selected. The largest quotient was that of Variable 5 and was equal to .0226. This value was entered in column b, row 4, of Worksheet IV. The calculations of Worksheet IV were completed and a new R of .8036 was derived. The addition of three variables to that of high school rank has given only an increase of .0583 to the original r of high school rank with the criterion.

The procedure was continued in order to determine the effect of adding a fifth variable to the battery of previously selected variables.

Step 16. To choose a fifth variable a_4, b_4, and c_4 were next calculated. The process was similar to that of Step 11. The a_4 entries were the correlations of the fourth selected variable (Variable 5) with each of the other variables including the criterion. These a_4 values with the signs reversed were entered in Worksheet V.

1. The formula for b_4 is analogous to those of b_3 and b_2 and is written as follows: $b_4 = a_4 \times b_1$ (given variable) $\times c_1$ (fourth selected variable) $\times b_2$ (given variable) $\times c_2$ (fourth selected variable) $\times b_3$ (given variable) $\times c_3$ (fourth selected variable). Checks are provided for the b_4 entries in a manner similar to Step 11. First, the entry in the criterion column should equal the V_4 entry of the fourth selected test. Both were equal to -.0910 for this problem. Second, the b_4 entry for the fourth selected variable

should equal the Z_4 entry for Variable 5 in Worksheet III. Both entries are .3669. Third, the Check Sum entry should equal the sum of the entries in the b_4 row. The addition of the b_4 entries gave a total of .4744 which is identical to the entry in the Check Sum column.

2. The c_4 entries were found by multiplying each b_4 entry by the negative reciprocal of the b_4 entry for the fourth selected variable (Variable 5). The division of -1.0000 by .3669 was carried out and found to be -2.7255. Checks for the c_4 entries are again provided in a manner similar to Step 11. First, the c_4 row entry of the fourth selected variable (Variable 5) should equal -1.0000. The value of this entry was -1.0000. Second, the c_4 entry in the Check Sum column should equal the sum of the c_4 row. -1.2930 was the entry in the Check Sum column and the sum of the c_4 row was also -1.2930. Third, the product of the b_4 and c_4 entries in the criterion column (-C) should equal the quotient $V_4^2 \div Z_4$ in absolute value. .0226 was equal to -.0226 in absolute value.

Step 17. Step 12 was repeated to find V_5 and Z_5. The formula for V_5 is $V_5 = V_4 - b_4$ (criterion) $\times c_4$ (each variable). The formula for Z_5 is $Z_5 = Z_4 - b_4$ (a given variable) $\times c_4$ (the same variable). Variable 4 had the largest $V_5^2 \div Z_5$ quotient and was, therefore, the fifth selected variable. The quotient (.0052) was entered in the column b, row 5 of Worksheet IV. The calculations of Worksheet IV were

completed and a new $\underline{R}$ of .8042 was derived. This multiple coefficient of correlation is but a very small increase over that given by the previously selected four variables. The difference is only .0006 which indicated that it would be futile to continue the operations to select any additional variables.

APPENDIX B

METHODS AND PROCEDURES OF THE MULTIPLE VALUE

The Procedure. A worksheet similar to that shown in Worksheet I was prepared. This worksheet is entitled "Basic Matrix" and contains the intercorrelations of the three variables. A worksheet similar to that of Worksheet II is prepared. The C column is the correlations of the variables with the criterion. In row A, column C the correlation of high school rank (.7650) with the criterion was entered. In row B, column C the correlation of the Cooperative English Test (college form) with the criterion was entered. This value was .6591. The correlation of the Cooperative English Test with the criterion (.4862) was entered in the row C, column C. The procedure then followed was as follows:

Step 1. The highest absolute value listed in the column C was circled. This value (.7650) was then multipled by each entry in the column of the basic matrix that corresponded with the row of the value that had been circled. The row in which the value .7650 had been circled was the A row of the worksheet so the A column in the basic matrix provided the multipliers. Each product with the sign reversed was added algebraically to the corresponding row of the C column, and the result was entered in the rows, A, B, and C of column 1. The product of the circled value times that of the total

entry in the A column of the basic matrix was entered in the x row of column C. The process may be illustrated as follows: (1) the circled value (.7650) which is in row A, column C is first multiplied by the A row, column A of the basic matrix (1.0000). This product (.7650) with the sign reversed (-.7650) is then added algebraically to the A row of column C and the result entered in row A of column 1. .7650 / (-.7650) = 0.

(2) The circled value (.7650) is multiplied by the B row, column A entry (.6758) of the basic matrix. This product (.5170) with the sign reversed (-.5170) is added algebraically to the row B entry (.6591) and the result (.1421) is entered in row B column 1. .7650 X .6758 = .5170. (-.5170) / (.6591) = .1421.

(3) The circled value (.7650) is multiplied by the row C, column A entry (.5728) of the basic matrix. This product (.4382) with the sign reversed (-.4382) is added to the row C, column 1 entry (.4862) and the result (.0480) is entered in row C, column 1. .7650 X .4862 = .4382. (-.4382) / (.4862) = .0480.

(4) The circled value (.7650) is multiplied by the Total row, column A entry (2.2486) and the result (1.9103) is entered in row x, column C.

Step 2. The entry in column 1 of the worksheet that had the highest absolute value was circled. This value (.1421) was multiplied by each entry of the rows A, B, and C of column B of the basic matrix. Column B of the basic matrix was

chosen because the circled value laid in the B row of the worksheet. The above products with the signs reversed were added corresponding row of column 1 and the results were entered in column 2. The circled value was multiplied by the Total entry of column B of the basic matrix and entered in the y row of column C of the worksheet. The entry of the y row of column C was subtracted from the entry in the x row of column C and the result was placed in row y of column 1. The total of the column 1 entries was entered in row x of column 1. A check was provided at this point. The entries of the x and y rows of column 1 should be equal. Differences in the last digit will appear but that is due to the "rounding off" that occurs. This difference should never be very large. The process of Step 2 may be illustrated as follows:

(1) The highest absolute value in column 1 is circled. This value (.1421), was located in row B so the column B entries of the basic matrix will each in turn be multiplied by .1421. The entry of row A, column B of the basic matrix (.6758) is multiplied by .1421 and the product with the sign reversed is added algebraically to row A, column 1 and the result (-.0960) is placed in row A of column 2. .1421 $\times$ .6758 = -.0960. 0 / .0960 = .0960.

(2) The highest absolute value circled is multiplied by the entry of row B, column B (1.0000) and the product with the sign reversed is added algebraically to the row A, column 1 entry (.1421) and the result (0) is placed in row B of col-

umn 2. .1421 X 1.0000 = .1421. (-.1421) ∕ .1421 = 0.

(3) The highest absolute value circled is multiplied by the entry of row C, column B (.8276) and the product (.1176) with the sign reversed is added algebraically to the row C, column 1 entry (.0480) and the result (-.0696) is placed in row C of column 2. .1421 X .8276 = .1176. (-.1176) ∕ .0480 = -.0696.

(4) The circled value is then multiplied by the Total entry of column B (2.5034) of the worksheet. This product (1.7202) is placed in the row y of column C and then subtracted from the row x entry (1.9103) of column C. The result (.1901) is placed in row y of column 2. Column 2 is added algebraically and the result (.1901) is placed in row x of column 1. A check is provided by the x and y entries of column 2. .1901 equaled .1901.

The other cycles or columns are computed in an identical fashion. The only difference to be encountered is that the product of the circled value in column 2 and the Total entry of the basic matrix will be placed in row z of the preceeding column and then subtracted from the row y entry of that column.

Results. One advantage of the Horst Technique is that a multiple R can be computed at any cycle. The multiple R^2 is derived simply by cumulatively squaring the circled values or, stated in another fashion, the circled values are squared and the multiple R^2 is the sum of the squares. The process may be halted at any point, depending upon the degree of accuracy

desired in the multiple $\underline{R}$. Ordinarily, carrying out the process until the circled value is .0003 will be all that is required.

Another advantage of the Horst Technique is that the beta coefficients (β column in Worksheet II) are gotten simply by the algebraic addition of all the circled values in a given row. Also, the multiple $\underline{R}$ may be checked by adding the multiplications of the values listed in the $\underline{C}$ column by the circled values in the same row as these $\underline{C}$ values. These multiplications are listed in the Worksheet II in the β_i column. These entries when added together should check the multiple $\underline{R}^2$. The sum of these entries for the problem was .6373 which checks very closely with the obtained multiple $\underline{R}^2$ of .6367.

WORKSHEET I

BASIC MATRIX FOR HORST TECHNIQUE

List of Variables

A High School Rank
B Cooperative English Test (College Form)
C Cooperative English Test (High School Form)

	A	B	C
A	1.0000	.6753	.5728
B	.6758	1.0000	.8276
C	.5728	.8276	1.0000
Totals	2.2486	2.5034	2.4404

WORKSHEET II HORST TECHNIQUE

Cycles

	C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	.7650	0	-.0960	0	-.0439	-48	-429	-161	-423	0	-193	-13	-189	-66	-187	0	-85	-2	-83	-26	-81
B	.6591	.1421	0	.0649	0	565	0	387	0	286	0	261	0	179	0	126	0	120	0	82	0
C	.4862	.0480	-.0696	-.0146	-.0683	0	-468	0	-320	-78	-315	0	-216	0	-148	-41	-145	0	-99	0	-68
x	1.9103	.1901	-.1656	.0503	-.1122	517	-897	226	-743	208	-508	248	-405	113	-335	85	-230	118	-182	56	-149
y	1.7202	.1901	-.1656	.0502	-.1123	516	-898	225	-744	207	-509	247	-406	112	-336	84	-231	117	-183	55	-150
z		.3557	.2159	-.1625	.1639	-1414	1123	-969	951	-716	756	-653	518	-448	420	-315	348	-300	238	-205	182

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	β	β_r
A	0	-37	2	-36	-10	-36	0	-16	1	-16	-4	-15	0	-7	0	-7	-2	-7	0	-3	0	-3	-1	-3	.5935	.4545
B	55	0	56	0	38	0	24	0	25	0	17	0	10	0	11	0	7	0	5	0	5	0	3	0	.4332	.2855
C	-22	-68	0	-46	0	-31	-10	-30	0	-21	0	0	-5	-13	0	-9	0	-6	-2	-6	0	-4	0	-2	-.2113	-.1027
x	33	-105	58	-82	28	-67	14	-46	26	-37	13	-14	5	-20	11	-16	5	-13	3	-9	5	-7	2	-5		.6373
y	32	-106	57	-83	27	-68	13	-47	25	-38	12	-29	3	-22	9	-19	3	-15	1	-12	2	-11	-1	-9		
z	-138	163	-140	110	-95	81	-60	72	-63	50	-43	34	-25	31	-28	22	-18	16	-13	14	13	10	-8			

* Entries in column 5 and each following column are actually four place decimals. The "zeros" and decimal points are not shown. Thus entries in column 5 should be as follows: -.0048, .0565, .0517, .0516, and .1414.

R^2 = .6367

R = .7979

WORKSHEET I

MULTIPLE REGRESSION EQUATION WORKSHEET

C = Criterion
3 = High school rank
2 = Cooperative English Test (college form)
6 = Cooperative English Test (high school form)
C_m = $\underline{c}_m$ row entries (Worksheet V, Appendix A)

	3	2	6	-C
C_1	-1.0000	-.6758	-.5728	.7650
C_2		-1.0000	-.3103	.2615
C_3			-1.0000	-.2135

APPENDIX C

CALCULATION OF A REGRESSION EQUATION FOR SELECTED HIGH SCHOOL AND UNIVERSITY VARIABLES

Procedure. A worksheet was constructed similar to that shown in Worksheet I which grouped the c row entries (Worksheet V, Appendix A) into a form which was adaptable for the calculation of the beta weights. With the values taken from the worksheet, the equations for the beta weights were as follows:

$$-1.0000\beta_3 - .6758\beta_2 + .7650 = 0$$

$$-1.0000\beta_2 - .0108\beta_6 + .2615 = 0$$

$$-1.0000\beta_6 - .2135 = 0$$

These equations when solved gave $\beta_3 = .5936$, $\beta_2 = .4346$, and $\beta_6 = -.2135$. These beta weights were converted to b weights by means of the formula $b_p = \frac{\sigma_c}{\sigma_p}\beta_p$. The sigmas of the formula refer to the standard deviations of the criterion and the variable being sought. The solving of the general equation above gave values for the b weights as follows: $b_3 = .0070$, $b_2 = .0145$, and $b_6 = -.0045$.

The regression equation in score form was

$$\bar{X}_c = b_3X_3 + b_2X_2 + b_6X_6 + K.$$

The constant K was calculated by means of the formula

$$K = M_c - b_3M_3 - b_2M_2 - b_6M_6 .$$

In the above formula M_c is the mean of the criterion, M_3 is the mean of high school rank, M_2 is the mean of the Cooper-

ative English Test (college form), and M_6 is the mean of the Cooperative English Test (high school form). The indicated values were substituted in the equation which was as follows:

$$K = 3.20 - .007(153.58) - .0145(171.55) + .0045(167.23.$$

$$K = .3902.$$

The regression equation in score form could now be written as $\bar{X}_c = .007X_3 + .0145X_2 - .0045X_6 + .3902$. In this equation, $\bar{X}_c$ represents the predicted grade, X_3 represents the high school rank, X_2 represents the total English scaled score obtained on the Cooperative English Test (college form), and X_6 represents the total English raw score obtained on the Cooperative English Test (high school form).

The formula for the standard error of estimate was as follows:

$$\sigma_{est} = \sigma_c\sqrt{1 - R^2} .$$

σ_c represents the standard deviation of the criterion (.7623) and R^2 is the square of the multiple coefficient of correlation, $(.7620)^2$. Substituting these values in the equation $\sigma_{est} = .7623\sqrt{1 - (.7620)^2}$ and $\sigma_{est} = .4657$.